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CANADIAN ELECTRONICS ENGINEERING

AUGUST 1958
A Maclean-Hunter publication
five dollars a year

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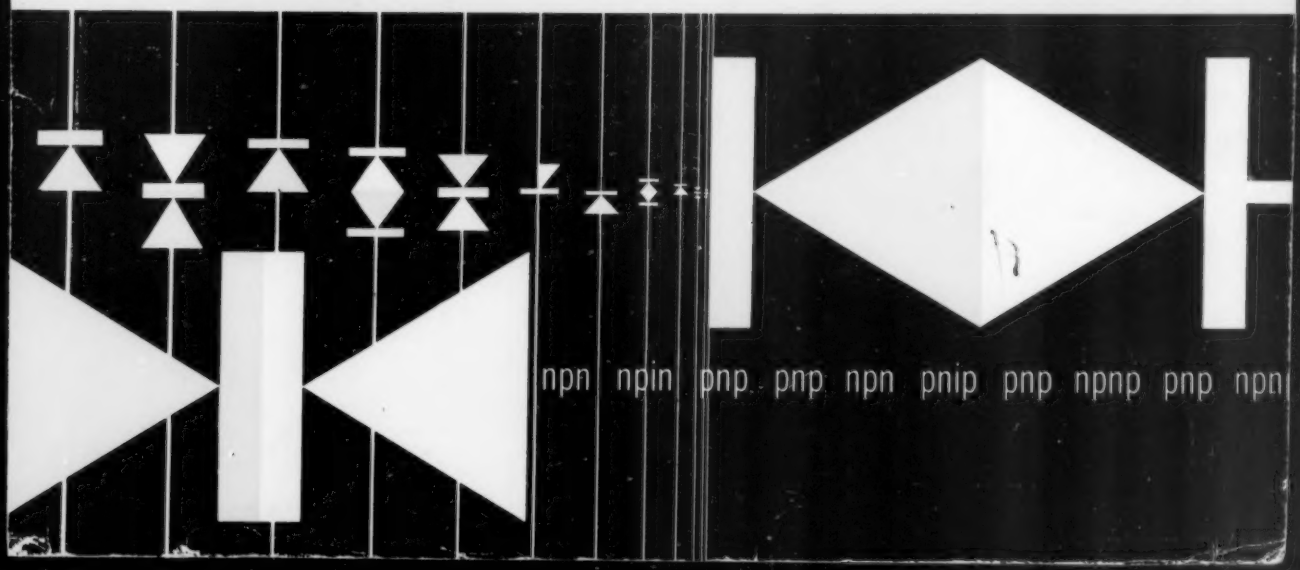
TTFA



RAYTHEON

RAYTHEON CANADA LIMITED announces the appointment of sales representatives for

- TRANSISTORS
- SEMICONDUCTOR DIODES
- SPECIAL PURPOSE TUBES
- MICROWAVE & POWER TUBES

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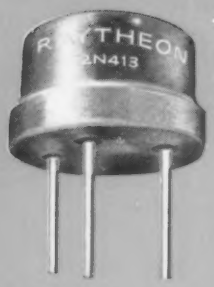

Raytheon perfected fusion-alloy process for supreme reliability. Life tests aggregating over 20,000,000 transistor hours show less than one open per 800,000 hours and no shorts.

A few examples of RAYTHEON Performance-Proved TRANSISTORS

Superior Reliability . . . Superior Performance

PNP GERMANIUM TRANSISTORS Temperature Range —65°C to +85°C
(Characteristics at 25°C unless otherwise noted)

TYPE	Typical Application	Dwg. No.	ABSOLUTE MAXIMUM RATINGS			TYPICAL CHARACTERISTICS				CUTOFF CURRENT		TYPE
			Pc (m w)	Vce (volts)	Ic (mA)	hfe (β)	fαb (Mc)	NF (db)	Gain (db)	Ico (μA)	at Vcb (volts)	
2N63	AF— AMPLIFIER	1	100	22	10	22	0.6	15	39	6	20	2N63
2N106	LOW NOISE AF AMPLIFIER	1	100	20	10	90	1.2	11	44	6	20	2N106
2N404	COMPUTER	5	120	24	100	—	4.0	—	—	5	12	2N404
2N413	GEN. PUR. RF AMPLIFIER	5	150	18	200	25	3	7*	10*	2	12	2N413
2N481	OSCILLATOR	5	50	12	20	—	4	—	—	3	12	2N481
2N485	CONVERTER	5	50	12	20	—	5	—	26	3	12	2N485

*Meas at 1.5 Mc.

PNP SILICON TRANSISTORS Temperature Range —65°C to +160°C
(Characteristics at 25°C unless otherwise noted)

2N327A	GEN. PUR. AMPLIFIER	7	337	50	100	15	0.3	18	32	0.005	30	2N327A
2N328A	GEN. PUR. AMPLIFIER	7	337	50	100	30	0.35	18	34	0.005	30	2N328A
2N329A	GEN. PUR. AMPLIFIER	7	337	50	100	60	0.6	18	36	0.005	30	2N329A

NPN SILICON TRANSISTORS
(Characteristics at 25°C unless otherwise noted)

2N619	GEN. PUR. AMPLIFIER	7	337	40	100	14	0.2	18	32	0.005	20	2N619
2N621	GEN. PUR. AMPLIFIER	7	337	20	100	50	0.5	18	36	0.005	20	2N621

Your Design is Better — Your Product performs Better — when you use RAYTHEON SEMICONDUCTORS

RAYTHEON
Excellence in Electronics

RAYTHEON CANADA LIMITED
61 Laurel St. East, Waterloo, Ontario.

For further information mark No. 28 on our Readers' Service Card

August 1958

Volume two, number 8

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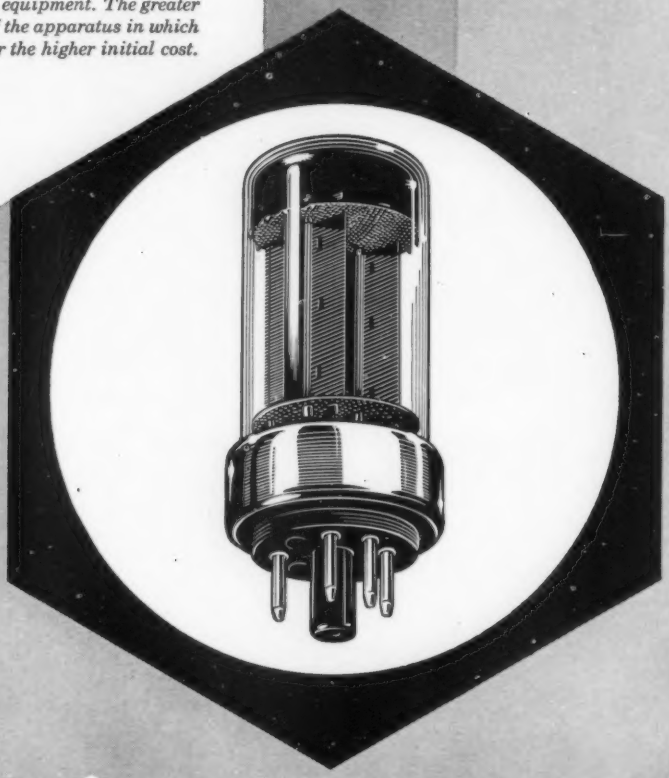
*** our cover design** *Transistor developments in the past ten years have resulted in a veritable parade of new items. Cover artists Davies and Bellinger visualized them as getting smaller and smaller as they rose in frequency*

Rogers 5AR4 Special Quality* general purpose rectifier is a universal replacement for numerous commonly used 5 volt rectifiers. Designed for efficiency and long life, the 5AR4 is of pressed glass base construction. Other features of the tube include a 5 volt 1.9 amp. heater; a peak inverse voltage of 1500 and a maximum r.m.s. current output of 250 mA. The 5AR4 has a low voltage drop ensuring maximum output. Write for full details on this special quality rectifier.

**Rogers Special Quality tubes are finding more and more applications in all types of professional equipment. The greater reliability and lower maintenance cost of the apparatus in which they are used more than compensates for the higher initial cost.*



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CANADIAN ELECTRONICS ENGINEERING

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contributors and special articles in this issue:

Out of what the authors referred to as "a rather haphazard collection of information," has grown our lead story on "Transistors reach for higher frequencies." The authors **A. L. Barry** and **P. J. Coppen** were beginning to feel rather snowed under by the large number of new semi-conductor devices being reported. They felt that some organization was necessary and began to compile the information for their own personal use. Fortunately, as the work progressed they had the idea that others could benefit from their search of the available literature. With this in mind they set to work and produced a top-notch review of high frequency transistors.

This is A. L. Barry's second contribution to CEE. His previous story on the preparation of single crystal silicon appeared in the issue of last October. Barry, born in Toronto, received his engineering training at Queen's University. He graduated in 1956 with a B.Sc. degree in Engineering Physics. Since that time he has been engaged in transistor physics research at NRC.

Co-author P. J. Coppen was born in London, England in 1931. He graduated from the University of Bristol in 1953 with the degree of B.Sc. in Physics. He worked on germanium and silicon transistor development at the research laboratories of the General Electric Company, Wembley. He came to Canada in 1957 and is now with DRB where he is working on the development of semiconductor devices.

E. V. Hird (New techniques allow wider use of radio carrier in telephone systems) is a native of Alberta. He served as a wireless electrical mechanic in the R. C. A. F. during the war and afterwards attended the University of British Columbia graduating with a B.A.Sc. in 1950. He was employed for six years with the Equipment Engineering Department of the B.C. Telephone Company, working on manual, automatic and toll terminal projects. He joined Lenkurt Electric Company of Canada in 1956 and now holds the position of Equipment Engineering Manager. In addition, he instructs a Vancouver Evening School class in advanced carrier telephone theory.

Hird

At the time photographs were being taken for our story "Legislators break the sound barrier," CEE, July, Mr. Ivor F. Cross, general manager of MacIvor Electronics Ltd. was in the Legislative Chambers carrying out checks on the sound equipment. He was pressed into service as a model, which makes our caption on page 22 wrong. We had identified him as the regular operator Ray Slye. Our apologies to both for the error.

Most of us do a lot of talking but few of us talk as effectively or with such good purpose as **H. L. Armstrong** (Is your uhh . . . IRE speech uhh . . . ready?). He has been teaching the art of effective speaking for the past 25 years in business schools, the YMCA, clubs and industry. It forms part of his duties at Canadian General Electric Co. Ltd., where he is employed as Specialist — Training and Education.

Armstrong

During the first World War he served overseas with the Canadian Army. However, the RCAF was fortunate enough to gain his services as a personnel manager during the second World War.

Mr. Armstrong is an elder of the Beach's Presbyterian Church, Toronto, and a leader in the Young People's Bible Class. He has served as secretary-treasurer of the Personnel Association of Toronto from 1940 to 1947, then as president in 1948 and 1949.

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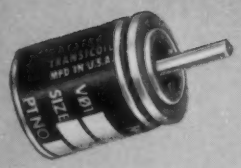
NEW



NEW TYPE 6 SERVO MOTORS

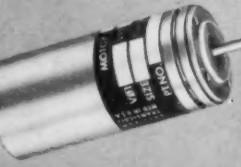
Here's one of the smallest precision servo motor series currently available. The new Daystrom Transicoil Type 6 Motors are wound for 26-, 33-, and 52-volt operation. Control phase is center tapped for operation with transistor drive. These Motors develop .125 oz-in. min. stall torque and 6200 RPM free speed. Each unit weighs only .9 oz. and is less than 1¼" overall.

NEW TYPE 8 INDUCTIVE POTENTIOMETER

This Inductive Potentiometer is an infinite resolution a-c potentiometer whose output voltage is linear rather than sinusoidal with the angle. Output voltage phase is dependent upon the direction of shaft displacement from null. When operated into load resistors not less than those specified, output is linear within .25% through an angular rotation of +85° through null to -85°.

NEW TYPE 8 SYNCHROS

The new Daystrom Transicoil Type 8 Synchro Line consists of transmitters, control transformers, differentials and repeaters. Dimensions equal to BuOrd Size 8. Operation: 115V 400 cycles or 26V 400 cycles. Accuracy of ± 10 minutes is standard. Other accuracies are available upon request. Corrosion resistant construction throughout. Conforms to MIL-E-5272-A. Operating temperature range is -54C to +125C. Higher temperature units also available.



NEW TYPE 11 INERTIAL DAMPED MOTOR

Here's inertial damping with no reduction in no-load speed! This new Type 11 Motor (BuOrd size 11) provides acceleration or deceleration damping in high-speed and high-gain servo systems. In non-critical applications, this motor can be used as a low-cost substitute for damping motor generators.

DATA SHEETS AVAILABLE *Write for complete specifications, mechanical data, dimensions and characteristics.*

5830

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A subsidiary of Daystrom, Incorporated.

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News highlights . . .

One year free radio service . . .

It's always a healthy sign when the benefits of technological advances are passed on to the purchaser. Canadian Admiral are now offering one-year's free service to buyers of their radios; they state advances in printed circuit reliability have made this possible.

Another Canadian development . . .

Described as a "unique Canadian contribution to integrated data processing," a transistorized information sorter has been installed in Ontario Hydro Commission's headquarters. Developed and manufactured by Northern Electric Co., the sorter will feed data to Hydro's Univac II computer.

Small motor plant closes down . . .

Canadian Westinghouse has announced the closing of its small motor plant at Stratford, Ont., by the end of the year. Stating that all motor production would be consolidated in the company's Hamilton facilities, vice-president J. D. Campbell blamed "highly competitive conditions prevailing in the motor market, which have been aggravated in recent years by the increasing share of the Canadian market that is being taken by foreign producers of low-cost and low-priced motors."

Teflon shapes in production

First Canadian manufacturer of rods, tubes and sheets from Du Pont "Teflon" tetrafluoroethylene resin is being undertaken by Joseph Robb and Co. Ltd., Montreal, plastics molders and extruders. Rods and tubes will be available in diameters from one-half inch to two inches and sheets up to three feet square.

EIA: Course for technicians

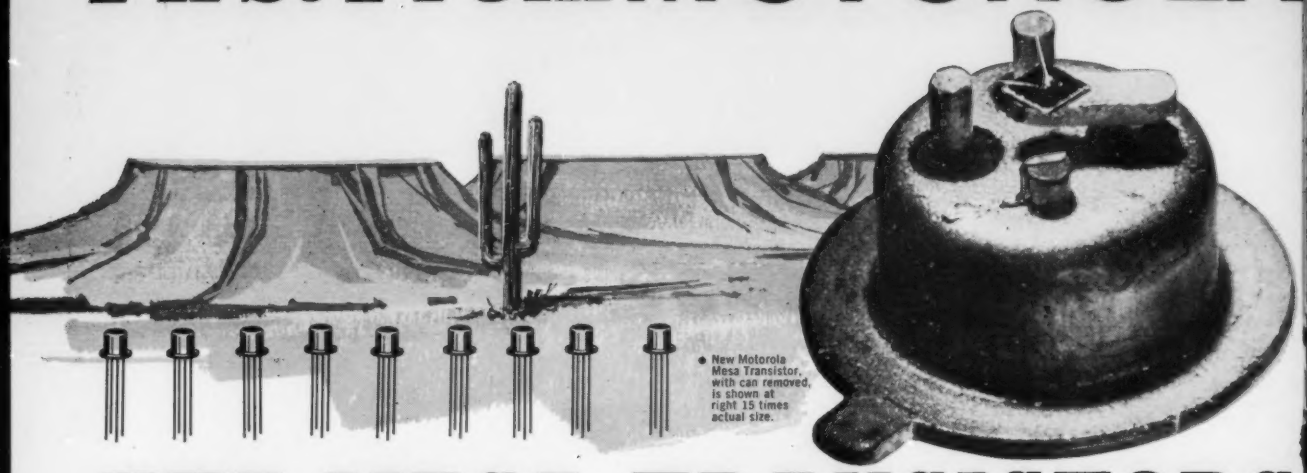
The Service Committee will sponsor an upgrading course for practicing television service technicians next winter. It will commence at Ryerson Institute of Technology, Toronto, in October and continue two nights a week for sixteen weeks. Including theory and practice in handling test equipment and servicing, the initial class will be limited to twenty students.

Applicants, who must have from three to five years' TV servicing experience, must pass a qualifying examination. Upon graduation, they will be awarded an industry-sponsored certificate of proficiency.

Technicians in the Metropolitan Toronto area who wish to apply should send the following information to the Electronic Industries Association, Room 410, 200 St. Clair Ave. W., Toronto 7: name, address, whether self-employed or a dealer-service technician, number of years employed, educational level reached (Grade 8, 9, etc., university or other education.)

Service technicians resident in other areas are invited to submit similar information to EIA, since long-range plans include extending the course to other schools across Canada.

First From MOTOROLA



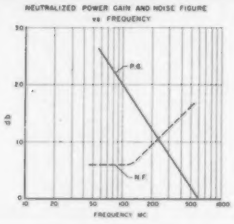
• New Motorola Mesa Transistor, with can removed, is shown at right 15 times actual size.

UHF MESA TRANSISTORS

2N700 LOW-NOISE HIGH-FREQUENCY AMPLIFIER					
TYPICAL CHARACTERISTICS					
TYPE	*f max*	*Power Gain*	*BV_{cn} @ 100μa*	*NF @ 200 mcs*	*Max Power*
2N700	600 mcs	12 db @ 200 mcs	33 volts	9 db	50 mw

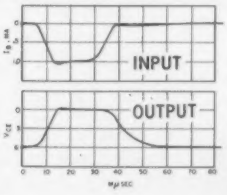
actual size

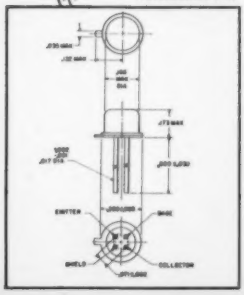
Operating Temperature
100°C case temperature with 12 mw dissipation
Germanium PNP



2N695 ULTRA HIGH-SPEED SWITCH					
TYPICAL CHARACTERISTICS					
TYPE	*BV_{cn}*	*I_{co} @ 5 volts*	*β sat. at 20 ma*	*I_C max*	*P_C*
2N695	20 volts	.8μa	30	20 ma	50 mw

Operating Temperature
100°C case temperature with 12 mw dissipation
Switching Times
in the order of 10 mμsec
Germanium PNP





FOR COMPLETE TECHNICAL INFORMATION
concerning Motorola Mesa Transistors contact the nearest Motorola regional office; or wire, write or phone
MOTOROLA, INC.,
5005 East McDowell Road, Phoenix, Ariz.
BRidge 5-4411 Teletype PX80.

the beginning of an exciting new transistor family

Extreme reliability — only high temperature materials used, process carefully controlled.

Higher operating temperatures.

Rugged — withstands 50,000G acceleration.

New header design provides effective interelectrode capacitance isolation . . . smaller inductance.

Low nuclear radiation susceptibility.

Modified JETEC 20 case . . . hermetically sealed.

Meets or exceeds mechanical and environmental requirements of MIL-T-19500A.

High uniformity — "Normal" instead of "selected" distribution.

A Revolutionary New Family
These are only the first of a wide variety of germanium Motorola Mesa Transistors coming your way soon.

"DEPENDABLE QUALITY - IN QUANTITY"

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ESterbrook 9-5200

HOLLYWOOD 28, CALIFORNIA
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HOllywood 5-3250

Canadian companies install new presidents

The new president of National Carbon Co. Division of Union Carbide Canada Ltd., is **Gordon W. Patterson.** A graduate of the University of Toronto, Mr. Patterson joined the Union Carbide organization in 1935. He served in various capacities in accounting, office service, field sales, advertising and public relations.

Since 1956 Mr. Patterson has been vice-president of National Carbon Company.

Mr. Eric Carnell has been appointed president and general manager of Ericsson Telephone Sales of Canada Limited, Montreal. He held executive positions previously with the parent company, L. M. Ericsson, Stockholm, Sweden, and headed that company's operation in Argentina for a number of years.

After 30 years with the organization, **Whitford S. Wyman** has been elected president of Linde Air Products Company, division of Union Carbide Canada Ltd. Mr. Wyman is a graduate in mechanical engineering from Cornell University. He has held various positions in research, development and plant supervision. Since 1956 Mr. Wyman has been vice-president and general manager.

RCAF man joins CDC

William F. Potts has been appointed aviation sales engineer at Computing Devices of Canada Ltd. He will be responsible for the sale of aviation radio and radar equipment in Canada. CDC represents the radio division of Bendix Corp. in Canada.

Mr. Potts is an electrical engineering graduate of Queen's University. From 1948 until 1957 he served in the RCAF in various telecommunications positions at Trenton, Clinton and Ottawa. Just prior to joining CDC, he was a sales engineer with Philco Corp. of Canada.

Vancouver section of IRE elects chairman

Lorne R. Kersey, Associate professor of electrical engineering in the University of British Columbia, has been elected chairman of the Vancouver section of the Institute of Radio Engineers for the coming year.

University of Toronto appoints Assistant professors

Among recent appointments in the University of Toronto's Faculty of Applied Science and Engineering are the following.

J. H. deLeeuw will be on the staff of the Institute of Aero Physics, where he has just completed work for his Ph.D. degree.

In the Department of Electrical Engineering, **Gordon R. Slemon** has been promoted to the rank of associate professor, and **J. L. Yen** to assistant professor.

Dr. Slemon was born in Bowmanville, Ontario and received his early education there. In 1946 he graduated from the University of Toronto with the degree of B.A.Sc. in electrical engineering. He received his Masters degree from Toronto, specializing in high voltage corona. His Ph.D. was earned at the University of London, England where he did work in non-linear networks. Dr. Slemon has served on the staffs of Imperial College, London (1949-53), Nova Scotia Technical College (1953-55) and the University of Toronto.

Dr. Yen came to Canada in 1948 after attending the Chao Tung University in China for a B.Sc. He took an M.A.Sc. at the University of Toronto in 1950 and a Ph.D. in 1953 for work on electromagnetic theory. His active research work is on microwave theory and system theory with current work on radio astronomy.

Sir Roy Dobson named managing director

The founder of A. V. Roe Canada, **Sir Roy Dobson,** has been appointed managing director of the parent Hawker Siddeley group.

It was in 1945 that Sir Roy started A. V. Roe Canada Ltd. Prior to that he had been managing director of A. V. Roe Manchester.

During its short span of years, the company has produced such outstanding products as the first jet-powered commercial transport (1949), the CF-100 (1950), the Avro Arrow (1958) and the Iroquois engine (nearing completion).

Quebec distributors elect leader

The Quebec Radio & Television Distributors Association, Inc., has elected **R. J. Clatworthy** of Philips Electronics Industries Ltd. as president. Mr. Clatsworthy has been with Philips since 1947 and was appointed Montreal branch manager in 1955.

Appointments at Rotor Electric

E. Barrett has been appointed general sales manager of the Electronics Division, Rotor Electric. He has been associated with retail and wholesale merchandising in the electronics field for the past 25 years.

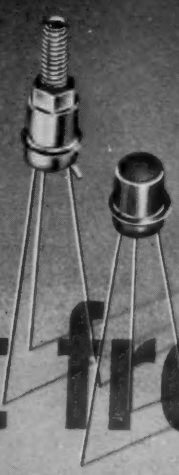
Marjorie Weil has been appointed vice-president, merchandising. In addition to her new post she retains the position of chief designer for the Hi-Fi Division and vice-president of Roto-Broil (Canada) Ltd.

Patterson

Carnell

Potts

Kersey



(shown actual size)

* first from PHILCO

Philco Design Increases Power Dissipation As Much As Four Times For New 2N671 Transistor!

- Exclusive Copper-to-Glass Hermetic Sealing
- One Watt Power Dissipation
- New Higher Voltages . . . Higher Currents

Philco is proud to introduce the 2N671, a new power transistor, rated conservatively at one watt maximum dissipation in a studded version of TO-9 (JETEC 30) type package.

With collector and emitter voltage ratings of —40 V dc and a maximum current rating of 2 amps., the 2N671 is especially engineered for high powered relays, relay drivers, drum or tape writers, pulse amplifiers, communications and core switching applications.

For applications with lower power requirements the 2N670 is available, without stud mounting, at dissipations of 300 mw.

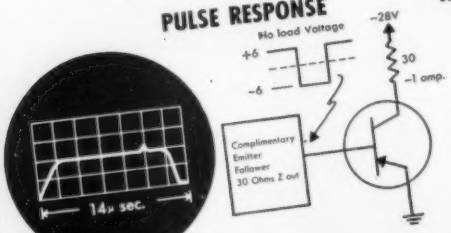
New Philco production techniques enable increases in thermal conductivity up to 8 times . . . power ratings as much as 4 times conventional ratings. These performance advantages can be applied to all classes of Philco transistors from audio frequencies through UHF.

If your application needs an optimum approach to semiconductor performance . . . more power, greater heat dissipation, or increased reliability . . . consult Philco first.

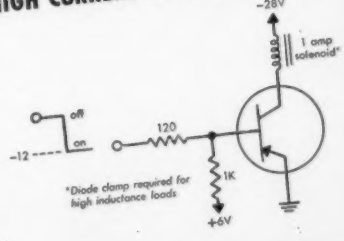
Make Philco your prime source of information for all transistor applications.

Write us for full information at address bottom of page.

PULSE RESPONSE



HIGH CURRENT SOLENOID DRIVER



† 200 mil. pin circle package TO-9-type

* more transistor power in standard† packages!

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OF CANADA, LIMITED
GOVERNMENT and INDUSTRIAL DEPT.
DON MILLS, ONTARIO

IRE Canadian Convention program will be most varied yet

The application to brain surgery of uhf sound waves and the choice of White Lake, B.C., as a site for Canada's largest radio telescope will be among the 120 subjects to be covered by scientists meeting in Toronto October 8, 9 and 10 for the Institute of Radio Engineers 1958 Canadian Convention and Exposition.

Details of the technical program and exposition were announced recently by Dr. George Sinclair, Chairman of the IRE Executive Committee responsible for planning the convention, and by A. P. H. Barclay, Technical Program Chairman. Twenty-five sessions covering fields ranging from medical electronics and education to cosmic rays and microwave systems will comprise the three-day technical program —see schedule on page 33.

Almost 90% of the exposition space allotted commercial exhibitors has been booked — see list of exhibitors on page 41. Other areas are being reserved for scientific agencies in Britain, the United States, Russia and France. It is hoped that these nations will accept invitations forwarded through diplomatic channels, and send to the convention exhibits devoted to space satellites, thermonuclear energy and other headline developments in the electronics and nucleonics fields.

Convention record

For the first time this year the full text of all technical papers presented will be reproduced with their illustrations in a convention record. This costly project will be underwritten by the IRE.

The education of engineers and scientists will again be a major topic discussed at the convention. Col. Kurt R. Swinton, vice-president of Encyclopaedia Britannica of Canada Ltd. and a leading authority on education, will be the banquet speaker on Thursday, October 9. During the technical program a panel of distinguished Canadian, United States and, possibly, British and Russian scientists will discuss the balance between theory and practice in engineering education.

Medical elecronics will be the subject of two of the technical sessions. William J. Fry, a scientist at the University of Illinois, will present the paper on the application of ultrahigh frequency sound waves to brain surgery. He will explain how focused beams of ultra-sound have been used to produce changes at any desired depth in the brain without disrupting intervening tissue.

Scientists from the National Research Council will describe the search for a suitable location for the Dominion Observatory's radio telescope and the reasons for the decision to locate at White Lake near Penticton, B.C.

Three sessions will be devoted to semiconductors and will include papers on theory, measurement, application and circuit design. Astronautics, stereo recording, reliability and engineering writing and speech are among other sessions to be held for the first time this year.

MEL becomes public company

Measurement Engineering Ltd., Arnprior, Ont., manufacturer of special electronic instruments, communication equipment and industrial controls, was converted from a private to a public company on June 30. New financing obtained will be used to strengthen the company's position.

Canadian reps. appointed by U. S. firms

Recent announcements of the appointment of Canadian sales representatives by manufacturing companies in the United States include:

Dayrand Ltd., Montreal — Amco Engineering Co. (Quebec); Electromechanical Products, Agincourt, Ont. —Burr Brown Research Corp., Levinthal Electronic Products, George T. Meillon, Inc.; Len Finkler & Co., Toronto—E-Z-Hook Test Products; J. R. Longstaffe Co. Ltd., Toronto—Scaico Controls, Inc.; Mel Sales Ltd., Arnprior, Ont.—Narda Ultrasonics Corp.

Raytheon representatives

Regional sales representatives for special purpose tubes, transistors, diodes, etc., appointed by Raytheon Canada Ltd., are: John R. Tilton Ltd., Toronto (East) and Chas. L. Thompson Ltd., Vancouver (West).

DDP electronics contracts for May 16-June 15

Unclassified contracts for $10,000 or more were awarded to: Atlas Instrument Corp. Ltd., electronic equipment, $20,682; Cdn. Aviation Electronics Ltd., spares for flight and instrument trainers, $45,232; Cdn. Marconi Co., electronic equipment, $22,293; C. N. Telegraphs, maintenance of teletype equipment, $50,000; Cdn. Westinghouse Co. Ltd., repair and overhaul of electronic equipment, $10,000; Alex. L. Clark Ltd., electronic equipment, $13,410; Collins Radio Co. of Canada Ltd., development, $82,420; Computing Devices of Canada Ltd., technical services, $12,760; Consolidated Electronic Equipment Co. Ltd., repair and overhaul of electronic equipment, $25,896; Field Aviation Co. Ltd., maintenance of telecom. equipment, $25,000; Northern Electric Co. Ltd., spares for teletype equipment, $15,000; Sperry Gyroscope Co. of Canada Ltd., repair and overhaul of radar equipment, $18,240.

Members of the IRE Technical Program Committee plan the schedule of technical sessions. Left to right: R. J. A. Turner, Philips Electronics Industries Ltd.; Frank A. Ford, Canadian General Electric Co. Ltd.; J. R. Bain, Engineered Sound Systems Ltd.; Chairman A. P. H. Barclay, Philips Electronics Industries Ltd.; W. E. Hodges, Electro-Acoustical Consultant; W. Ornstein, Canadian Marconi Co. Other Committee members are: L. Kerridge, Ryerson Institute of Technology; Vice-chairman D. K. Ritchie, Ferranti Electric Ltd.; G. Sinclair, Sinclair Radio Laboratories Ltd.

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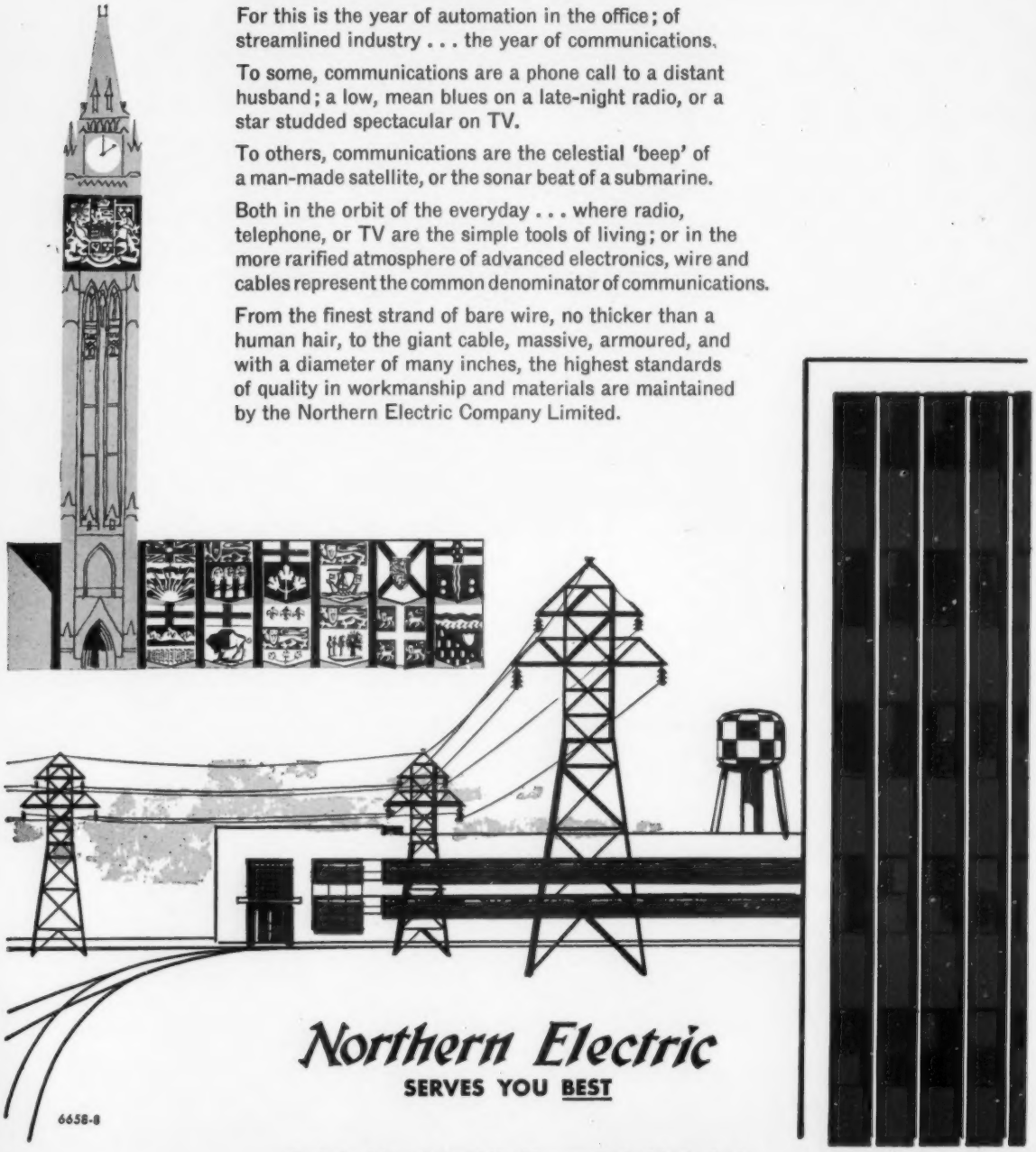

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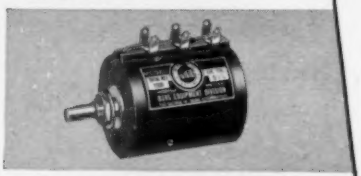

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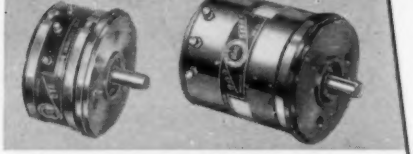

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Shafts — ¼" dia.
Bushing Mount — ⅞" long
Servo Mount — ⅝" long

LINEARITY ACCURACY: Single-turn — ±.5% (independent)
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10-Turn — .05% (independent, zero based, or absolute reference).

RESISTANCES: Single-Turn — 50 to 50,000 ohms
3-Turn — 15 to 60,000 ohms
10-Turn — 50 to 300,000 ohms

TEMPERATURE LIMITS: Tested to 350° F.

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SIZE: 1¼" x 5/16" x 17/64"

RESISTANCES: 10 to 30,000 ohms standard. Other values on special order.
Tolerances — ±5% 100 ohms and over
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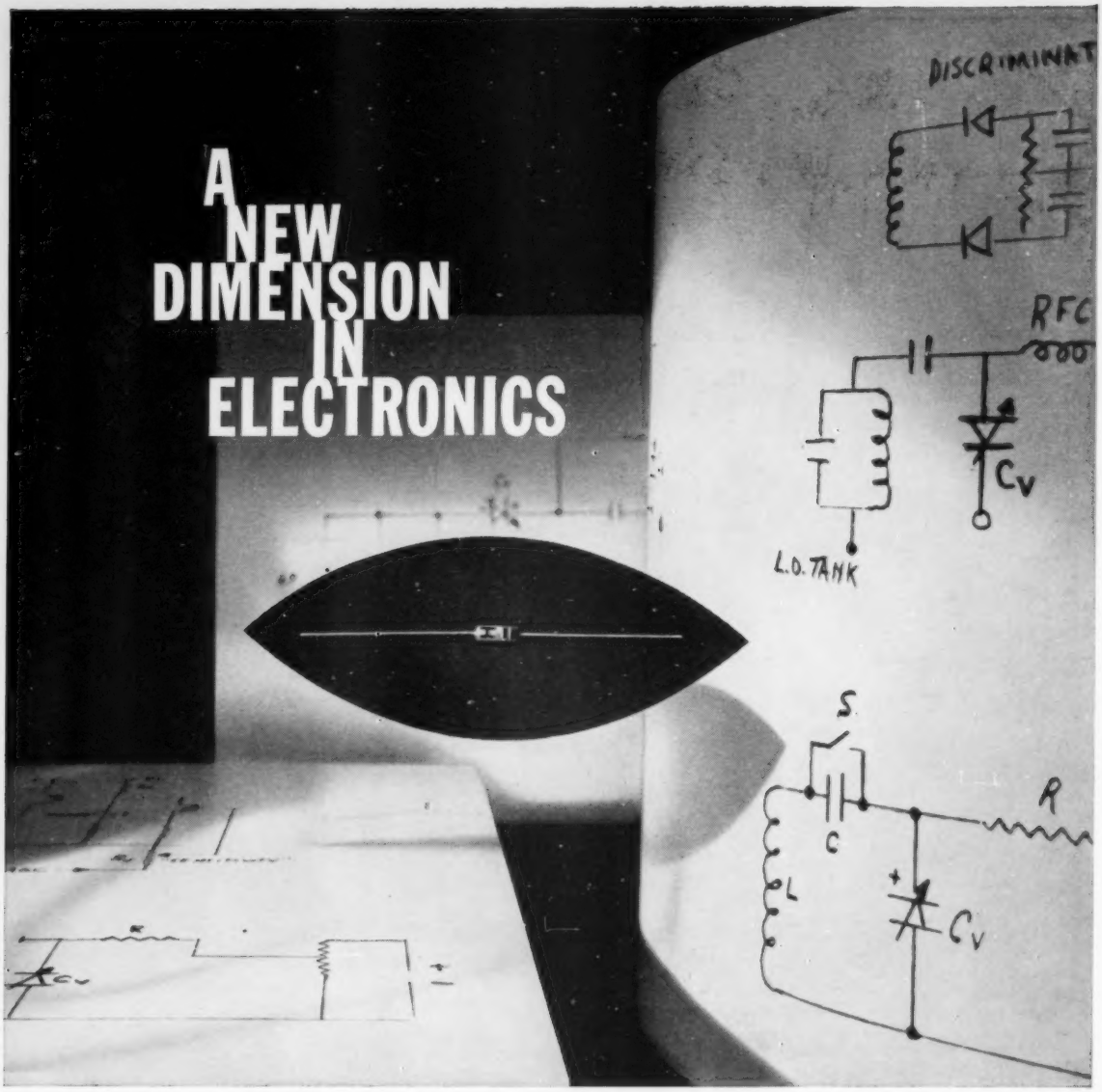

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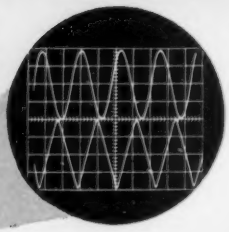
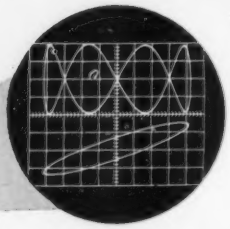


Dual display on linear time base.



Dual display for X-Y curves.

Here are a few uses for the Type 502:

IN ELECTRONICS—Use the Type 502 as a general-purpose oscilloscope and also to show simultaneously the waveforms at any two points in a circuit, e.g. input and output, opposite sides of a push-pull circuit, trigger and triggered waveform, etc.

IN MECHANICS—Display, compare, and measure outputs of two transducers on the same time base; plot one transducer output against another—pressure against volume or temperature for instance; measure phase angles, frequency differences, etc.

IN MEDICINE—Display, compare, and measure stimulus and reaction, or the outputs of two probes, on the same time base; use differential input to cancel out common-mode signals, or to eliminate the need for a common terminal; use in routine investigations, etc.

IN ALL FIELDS—The Type 502 can save you more than its cost in time—in as little as one application!

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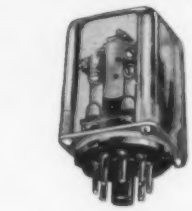

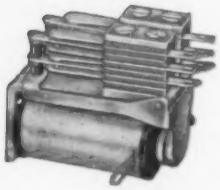

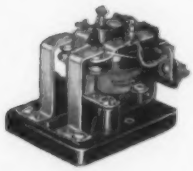

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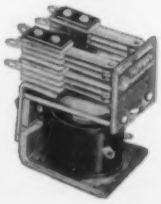

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Tools for Canadian scientists

It was recently announced that the Canadian Association of Physicists will shortly submit to the Federal Government a proposal that will involve an expenditure of around $20 million. They will suggest that as a co-operative effort, with several Canadian universities and the Federal Government providing funds, a laboratory be constructed housing an accelerator capable of producing particle energies as high as ten billion electron volts. The objective is to enable Canada to keep pace with other countries in fundamental nuclear research, an area in which our scientists are already making significant contributions.

We wish them every success in this venture, since we recognize the vital importance of research to the country's economy. In particular, the need for intensification of research activity in the field of electronics grows daily in importance. "Future prosperity of Canada depends on research in electronics" was the headline with which we introduced last month's report of the Electronic Industries Association of Canada annual meeting. It was keyed to the remarks of retiring president W. H. Jeffery, who amply justified such a far-reaching suggestion.

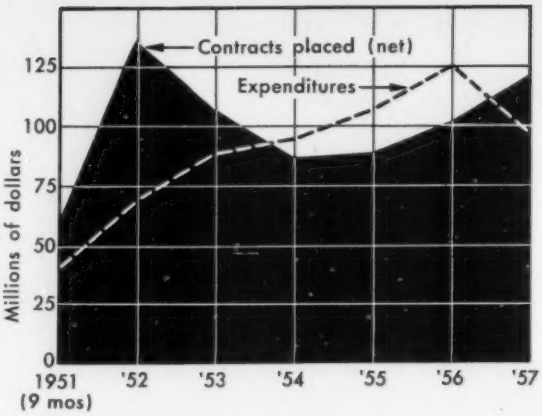
If this premise is accepted, the question inevitably arises of where the work is to be done. Current activity is largely concentrated in government scientific agencies such as the National Research Council and the Defence Research Board, and in the universities. Some manufacturing companies have already set up research laboratories within their own organizations, but we believe that the industry must take on an increasing share of the load.

However, the cost will be high — for personnel as well as for equipment — and many companies may feel that present economic conditions do not justify the required ploughing-back of current profits. We therefore suggest that some co-operative effort — as will be proposed by the physicists — is essential. Possibly an appropriate first step would be to hold an industry-wide conference, with representatives present from the government departments concerned and from the universities.

Canadian Electronics Engineering will be pleased to hear from its readers of their opinions on this proposal. Their views will be passed on to EIA, since any such conference should, we believe, be held under the auspices of the established industry organization.

THE EDITOR

Contracts placed:	Thousands of Dollars 1957	1956
Canada	103,374	88,328
United States	18,964	15,285
United Kingdom	721	1,342
Total, all countries	123,209	105,304
Expenditures on contracts		
Canada	85,534	117,400
United States	11,356	9,730
United Kingdom	1,636	2,432
Total, all countries	98,676	129,670



Above: Vital statistics from the report. At right: Trends in procurement totals over several years. Both apply to DDP's electronics and communication equipment program.

Defense electronics—the 1957 story

The report of the Department of Defence Production for the period January 1 to December 31, 1957, shows the wide range of electronic and communication equipment being procured for the Services. CEE is pleased to publish the relevant extracts for the information of readers who do not have access to a copy of the report

During 1957 there was a decline in the purchasing and production of electronic equipment for defense purposes as compared with the high level of 1956. This was due to several factors, the most important of which were the completion of the Mid-Canada early warning radar line, the postponement of production for the radar improvement program, and the approaching completion of existing production contracts. In addition, some decline resulted from the changeover from the Velvet Glove to the Sparrow II missile program. The decline, however, was partially offset by increased expenditure on the development of the integrated electronic system for the CF-105 Arrow aircraft. The effect of the decline in 1957 was an underloading of the defense electronic capabilities that had been built up gradually by Canadian industry since 1952. Special consideration was given to the handling of the new build-up that will be needed as a result of an expected increase in expenditure in 1958.

The development of the integrated electronic system (Astra) for Arrow aircraft, which began in mid-1956, continued through the year fairly closely to schedule. In order to meet probable Arrow production schedules, preproduction and production of Astra will overlap development. As a result, considerable effort was expended, in co-operation with the Royal Canadian Air Force, in defining the areas of work for which preproduction must be started in 1958.

The Sparrow missile electronics program commenced in the spring of 1957. Limited tooling and a preproduction-type approval program were authorized, but a contract for production was not placed due to uncertainties of the type and quantity required. *(Note: contract has now been placed; see CEE, May, 1958, page 9 — Ed.).* A similar type approval program for certain vital components (notably klystrons and magnetrons) was also initiated and progress was satisfactory. Some missile fuse development work was continued pending a decision on the production requirements for the Sparrow fuse.

Delivery of the CF-100 flight simulators continued through 1957 and a contract was let for a unit for the Belgian Air Force. Procurement of CP-107 flight simulators was reviewed and a portion of the requirements was approved. A contract was issued for the installation of a communication system at the Cold Lake, Alberta, instrument range. This range is to be used for measuring the flight performance of missiles, rockets and aircraft.

Progress on the ultra high frequency (UHF) conversion program was satisfactory, with procurement of ground-based equipment nearing completion and on-site installations well under way. A production program for modern multi-channel airborne UHF equipment was begun and deliveries are expected to start in 1958. Production to meet other service communication requirements was pursued actively and arrangements were made to procure in the United Kingdom interim equipment to meet army requirements in Europe. Substantial contracts for carrier equipment and communication centres were placed on behalf of the United States Government with Canadian industry.

Production of the electronic equipment for the St. Laurent class destroyer escorts, which began in 1952, continued during the year and is expected to be completed in 1958. Some purchases of naval radar fire control were made initially in the United States and continued in Canadian plants. The possibility of Canadian production of some new requirements was explored.

A contract for airborne radar equipment was completed by the end of 1957, leaving only support spares to be provided in 1958. This radar is for the CS2F Tracker aircraft. Contracts for magnetic airborne detection equipment were placed in 1957, with production scheduled through 1959. Sponsored by a development contract from this Department, Canadian industry produced airborne doppler navigational equipment which is considered to be a forerunner in this field.

The Mid-Canada early warning radar line is now an integral part of the North American defense network, and during the year an extensive program was carried out to complete the outstanding items of a construction nature. Two civilian contractors were selected to be responsible for carrying out maintenance and supply supporting services on the line for the RCAF. Maintenance contracts to provide support for Canadian-manned Pinetree radar stations were in effect during the year. Contracts were also awarded to support the Pinetree line stations manned by the United States Air Force. END

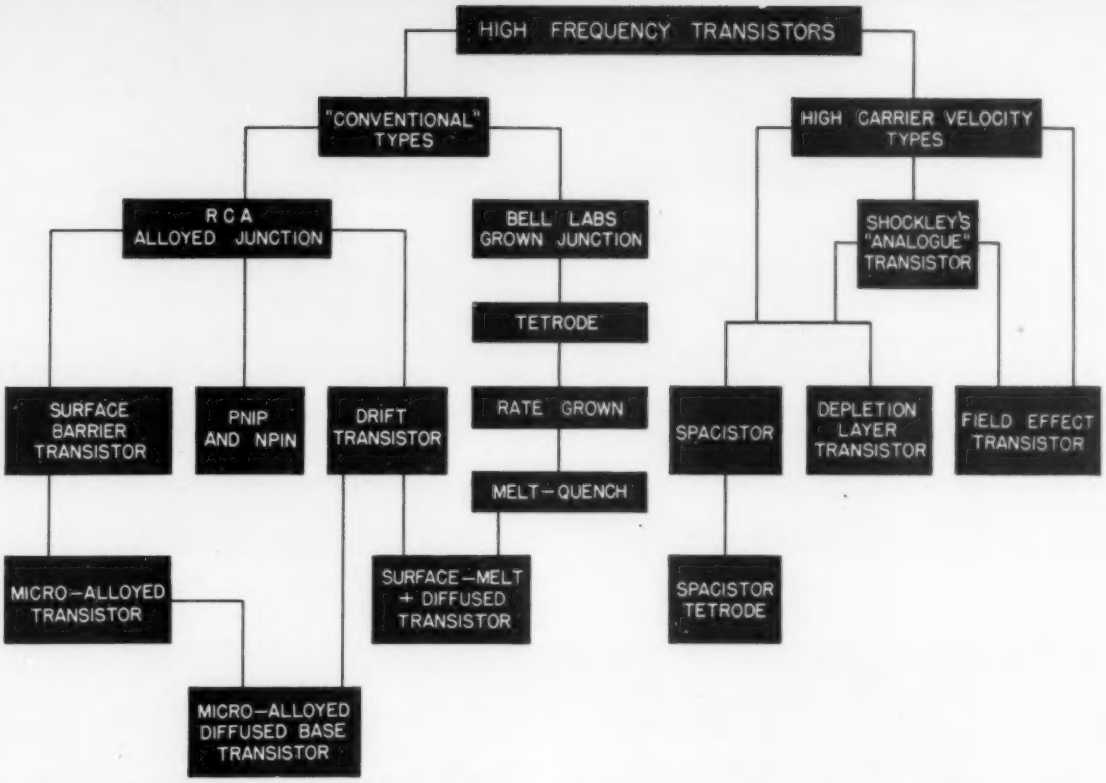


Fig. 1. High frequency transistors can be divided into two main groups as shown in this development flow chart

Review of recent developments

Transistors reach for higher frequencies

A. L. BARRY* & P. J. COPPEN†

The high frequency limit of a transistor is determined by the transit time of the carriers going from the emitter to the collector, and upon the deviation from the mean velocity. These effects are largely dependent upon the configuration of the transistor. Spacistor tetrodes are the most recent development and show good promise for extending the upper frequency limit

Since the first announcement of the invention of the transistor by Bardeen and Brattain in 1948, much has been done to improve the high frequency and power handling capabilities of this and related devices. It is proposed to present here a chronological review of developments in the field of high frequency semiconductor amplifying devices beginning with the first junction transistor in 1951. Detailed descriptions of individual devices have been sacrificed in order to include a more comprehensive coverage of different approaches to the problem, even though some of these are still in the experimental stage. A list of references is appended from which the interested reader may find further details. It will be assumed that the reader has some knowledge of basic semiconductor theory, including the qualitative behavior of p-n junctions, such as may be found in the elementary literature on the subject.

*National Research Council, Ottawa.
†Defence Research Board, Ottawa.

Frequency limiting parameters

The junction transistor has undergone considerable development since the first practical examples were reported[1]. This is especially so for the high frequency device. From frequencies of the order of a few megacycles per second, performance has improved so that oscillations at over 1,000 mc and amplification at a few hundred megacycles per second can be obtained.

In the conventional transistor the mobile carriers injected into the base region from the emitter cross to the collector principally by diffusion. (This diffusion may, or may not, be aided by a relatively low electric field, as explained later.) Since the diffusion velocities of the carriers are distributed about a mean velocity, a pulse of carriers injected at the emitter will be broadened by the time the

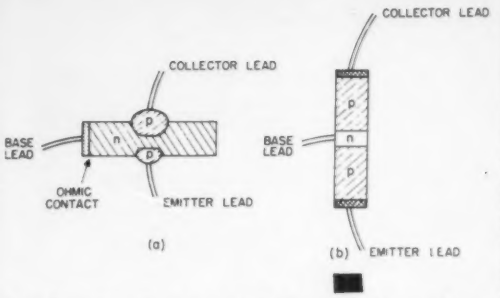


Fig. 2. RCA alloyed (a) & Bell grown (b) transistors

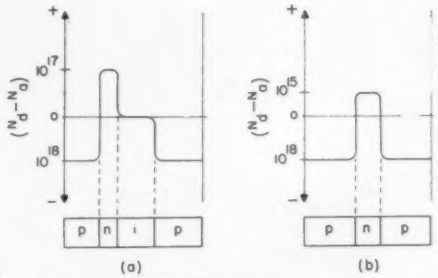


Fig. 3. Net impurity distribution in (a) p-n-i-p and (b) conventional structures

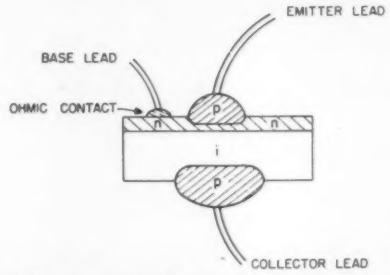


Fig. 4. Construction of p-n-i-p transistor

pulse reaches the collector by an amount depending on the transit time of the pulse across the base. Hence if a series of pulses is emitted with a frequency $f \sim \frac{1}{t}$, where t is the mean transit time, the pulses will have become almost indistinguishable, and the signal amplitude will have decreased markedly. It has been shown[2] that $f\alpha \propto 1/w^2$, where $f\alpha$ is the alpha cut-off frequency of the device, defined as the frequency where alpha has dropped by 3 db from its low frequency value, and w is the base width. The importance of a narrow base width is apparent.

Two other frequency limiting parameters are collector capacitance and base resistance. The current which charges the collector capacitance flows through the base resistance, producing a frequency dependent feedback voltage on the emitter. Also, the RC circuit formed by the collector capacitance and the collector resistance will attenuate a signal, although the magnitude of this effect is small compared with that of the others. Hence collector capacitance and base resistance should be as small as possible.

Most of the high frequency developments have been devoted to reducing the three parameters mentioned above; this is primarily a geometrical problem. Transistors whose improved frequency response is due to geometrical refinements we shall call "conventional." There is a class of devices in which very short transit times are obtained by the use of high electric fields, rather than by small size alone. These we have called "high carrier velocity" devices. The chronological developments in these two classes are depicted in Fig. 1.

"CONVENTIONAL" TRANSISTORS

Early work on alloyed junction transistors was carried out by RCA, and resulted in a p-n-p device first reported in 1952[3]. These transistors differed from the n-p-n transistor first reported by Shockley et al mainly in the geometry, which resulted from a very different fabrication technique. The two different geometries are shown in Fig. 2. The RCA type is made by alloying an acceptor impurity (usually indium) into opposite sides of an n-type germanium wafer, with the n-material between the junctions so formed comprising the base of the transistor. The thickness and shape of this base region may be controlled by varying the sizes of the indium dots and the alloying cycle. Further refinements in techniques allowed greater control of the junction geometry and hence of the base width. As a result of this, transistors were produced which had about 12 db gain available at 10 mc, and from which oscillations could be obtained between 40 and 75 mc.

p-n-i-p and n-p-i-n transistors

The development of the p-n-i-p transistor (and its homologue the n-p-i-n) as first announced by J. M. Early in 1954[4] was an attempt to raise the frequency limits of a transistor without having the power handling capabilities suffer. The parameters limiting the frequency and power of transistors, namely base resistance, collector capacitance, transit time, and collector voltage and current, may be seen to be interdependent. For example, decreasing the base thickness to shorten transit time will increase base resistance. Also, reducing the base resistivity to decrease base resistance lowers the maximum collector voltage; and decreasing the collector junction area in order to reduce collector capacitance lowers the maximum collector current. Both of these effects limit the available power. Some of these restrictions may be eliminated by employing the p-n-i-p structure which consists of a relatively thick layer of intrinsic semiconductor separating the base and the collector. Figs. 3(a) and (b) show the net impurity concentration in the p-n-i-p and conventional p-n-p structures, respectively.

The collector breakdown voltage increases for increasing base resistivity. Since the base, as seen from the collector, is the high resistivity intrinsic region, the p-n-i-p device will have a higher breakdown (and therefore operating) voltage than the p-n-p device. The base resistance is held low by the very low resistivity of the n-type skin on the "i" wafer. Similarly, collector capacitance, which decreases for higher base resistivity, will be lower in the p-n-i-p than in the p-n-p device for equal collector areas. This means that either one of a lower collector capacitance, or a higher collector current may be obtained without detriment to the other. Fig. 4 shows construction details of a p-n-i-p unit. Preliminary units had alpha cut-off frequencies of the order of 25 mc, with base resistance and collector capacitance of 60 ohms and 1.4 uuf respectively. Oscillation was possible up to 100 mc, and 20 db gain was available at 10 mc with a bandwidth of 3 mc between the 3 db points. Early[4] predicted that with further development p-n-i-p germanium triodes might serve as oscillators, and perhaps amplifiers, at frequencies as high as 3,000 mc.

Surface-barrier transistors

The surface-barrier transistor was developed by the Philco Research Laboratories and first reported in a series

of five papers in 1953[5]. This device has become of considerable practical importance because of its frequency characteristics. The outstanding constructional feature of the surface-barrier transistor is the very thin base region obtainable by a process known as "jet etching," illustrated in Fig. 5. Jets of a salt solution (for example, indium sulphate) impinge on an n-type germanium wafer, and if a direct current of suitable polarity is passed between the solution and the wafer, etching takes place. By this method the region of germanium between the jets may be reduced to a thickness of only a few microns. Control of the etching current, solution concentration, and ambient light intensity allows the desired thickness of this region to be obtained within 5%. When this thickness has been reached the etching current is reversed. This immediately stops the etching, and begins plating the metal of the salt (indium in this example) onto the clean germanium surface. When sufficient metal has been plated the wafer is removed, washed, and leads are attached. Fig. 6 shows the completed surface-barrier transistor. Note that the device consists of n-type germanium only, with no p-n junctions. Operation of the device depends upon the injection of holes into the germanium by the metal emitter contact, and subsequent collection of these holes by the metal collector contact. Hole injection by a large area metal contact is dependent on the existence of electrons bound in surface energy levels. A discussion of this is beyond the scope of this article and further details may be found in references 5 and 6.

The name "surface-barrier transistor" comes from the fact that the potential barriers giving rise to emission and collection of holes are located at the surface of the germanium, rather than within the semiconductor as with p-n-p junction transistor.

Surface-barrier transistors produced by the above-mentioned techniques have proved to be very practical devices. Commercial units are available with alpha cut-off frequencies ranging from 30 to over 100 mc.

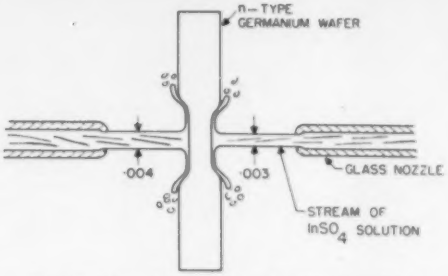


Fig. 5. Jet-etching surface barrier transistor

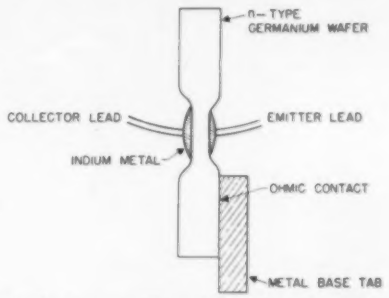


Fig. 6. Cross section of completed transistor

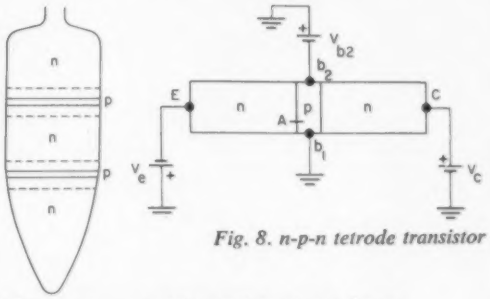


Fig. 8. n-p-n tetrode transistor

Fig. 7. n-type crystal containing two p-layers

Grown transistors

The basic structure for some early germanium junction transistors was produced while growing the germanium crystal[7, 8]. For an n-p-n transistor, molten germanium is doped with a donor impurity such as antimony, and a section of n-type crystal is grown. Sufficient of an acceptor impurity, such as gallium, is added so that the effect of the antimony is swamped and p-type material is grown. This p-type germanium will form the base of the n-p-n transistor and so the layer grown must be thin, about .001 inch thick at the most. As soon as this p-layer is of suitable thickness, more antimony is added to convert to n-type. A wafer containing the p-n junctions is cut out of the crystal as shown in Fig. 7, and then n-p-n bars may be cut from this wafer.

An important parameter in crystal growth is the segregation coefficient k for an impurity. This is defined as

$$k = \frac{\text{impurity concentration in the solid}}{\text{impurity concentration in the liquid}}$$

for equilibrium between the solid and liquid. Knowing k for the impurities of interest, it is possible to dope the melt so as to produce a desired resistivity in each of the three regions. Not many successive p-layers can be grown, since the continued conversion of conductivity type leads to a very high total impurity content, so that long minority carrier lifetime and high mobility, important for good transistor performance, are impaired. A method of fabrication which overcomes this difficulty and also allows thinner layers to be grown is described later.

The n-p-n bars made in this way were about 1 mm square with typical base widths of about 15 microns (25 microns = .001 inch, approximately). Low frequency gains of about 50 db were obtained, but the maximum operating frequency was largely determined by the collector capacitance rather than the transit time.

Tetrode transistors

In the junction transistor tetrode[9] a significant advance in frequency response was made, compared with that of the conventional grown transistor, primarily by reducing base resistance. In Fig. 8 are shown the three connections normally made to the three regions of a bar-type transistor, b_1 being the usual base contact. A fourth contact b_2 is now made to the base layer opposite b_1, and a bias $V_{b_2} \sim -6$ volts, which is greater than V_e, is applied. A voltage gradient then exists across the base between b_1 and b_2 such that the emitter junction is reverse biased between b_2 and a point A, and forward biased between A and b_1. Since V_{b_2} is much greater than V_e (normally $V_e \sim -0.1$v), A is evidently much nearer b_1 than b_2, hence the active area of the emitter has been greatly reduced, and concentrated in the region of the base contact b_1.

For the device discussed in the reference quoted, the bar was approximately .010 inches square, so for the biases mentioned above, the point A was about .0002 inches away from b_1. The base resistance was reduced from about 1,100 ohms with $V_{b_2} = 0$ to less than 100 ohms with $V_{b_2} \sim -6$v.

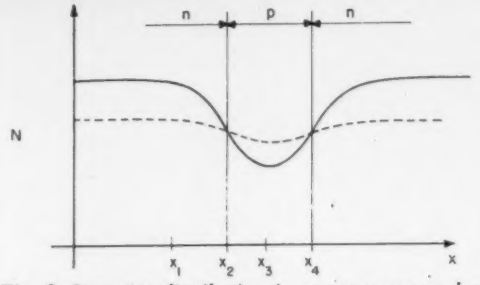


Fig. 9. Impurity distribution in npn rate grown bar

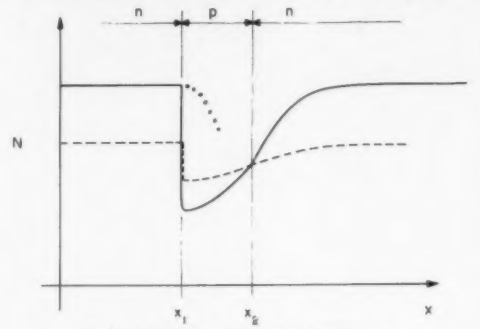


Fig. 10. Impurity distribution in a 'melt back and rate grown" bar

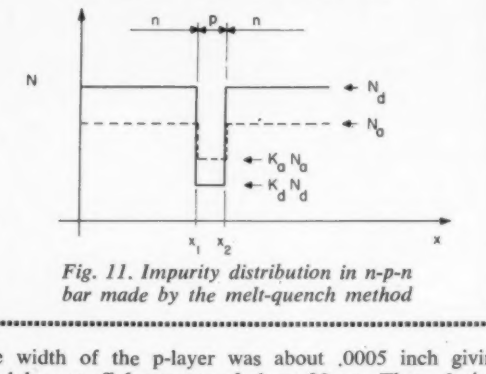


Fig. 11. Impurity distribution in n-p-n bar made by the melt-quench method

The width of the p-layer was about .0005 inch giving an alpha cut-off frequency of about 20 mc. These devices would oscillate up to 130 mc and tuned amplifiers at 50 mc had gains up to 12 db. These figures represent a tenfold extension in operating range compared with the performance of the triode structure for the same geometry.

Rate grown transistors

A technique whereby base width of 3 microns can be produced is known as rate growing. This method depends on the fact that the segregation coefficients of some of the impurities used for doping germanium and silicon are dependent on the growth rate of the crystal. For instance, the segregation coefficient for antimony in germanium increases by a factor of 2½ as the growth rate increases from one to nine inches per hour, whereas p-type impurities such as gallium and indium show much smaller changes[10]. The segregation coefficient for gallium in germanium is very nearly constant over the above growth rate range. Hence, by doping a germanium melt with a suitable proportion of antimony and gallium, a fast growth rate produces n-type material, and a slow rate produces p-type material. By suitable modulation of the growth rate, many p-n junctions can be grown in one crystal. However, a simple transition from fast growth to slow, then back to fast again, is not suitable for n-p-n transistors because of the inertia of the apparatus. In Fig. 9 concentration of impurity, N, is plotted against distance along the crystal, the continuous line referring to donors, the dashed line to acceptors. At x_1, the growth rate is decreased, giving a junction at x_2 and p-material between x_2 and x_4. At x_3 the growth rate is speeded up, giving a junction at x_4. Owing to the time it takes for the growth rate to alter, two graded junctions result, neither of which is very desirable for an emitter junction. This can be overcome by modifying the technique[11].

In Fig. 10 the heavy line refers again to donors and the dashed line to acceptors. The growth rate is reduced to zero, the donor concentration falling off as the dotted line shows. The crystal is then pushed back into the melt until it has remelted back to x_1, say. The growth is now started again, and is increased to its previous "n-growing" value as quickly as possible. If the doping of the melt has been arranged such that near zero growth rates are required for p-material, then the time during which the p-material will grow is short, hence the p-layer is thin. This technique produces not only very thin base layers, but also one abrupt p-n junction which is advantageous for the emitter junction. Also, the net acceptor concentration in the base decreases from the emitter to the collector. This has certain advantages which will be referred to later.

It has been found desirable to decrease the resistivity of the base layer in order to reduce base resistance. For this, an acceptor with a segregation coefficient larger than that for gallium is required. k for gallium is $\simeq 0.1$, k for boron is > 1.0. (This means that boron is more soluble in solid germanium than in the liquid.) Also, as the growth rate increases, the segregation coefficient for boron decreases. Using the technique described above, it has been possible to grow base layers doped with boron with resistivities less by a factor of 10 than those for gallium doped bases. Since for gallium $k < 1$, its concentration in the melt increases as the crystal is grown. For boron, because $k > 1$, the melt becomes depleted of boron, and so successive p-layers become progressively thinner and less heavily doped. Tetrodes made from n-p-n structures produced in this way have oscillated at frequencies about 500 mc, some above 1,000 mc. Typical alpha is 0.95 at 30 mc.

Melt-quench transistors

Another technique for fabricating thin-base layers in bar type transistors is the "Melt-Quench" method[13]. Suppose we have a bar of germanium doped with concentration N_d of donors and N_a of acceptors. Let $N_d > N_a$ so that the bar is n-type. The bar is melted from the right to the ordinate x_1 in Fig. 11. The impurity concentrations in the liquid will be the same as in the solid. If the bar starts to re-freeze slowly, so that the solid at the liquid-solid interface is always in equilibrium with the liquid, then the donor and acceptor concentrations in the re-frozen layer will be $k_d N_d$ and $k_a N_a$ respectively, provided that the volume of liquid re-frozen is small compared with the total volume of liquid. Here k_d and k_a are the donor and acceptor segregation coefficients, respectively.

If we have the conditions $N_d > N_a$, and $k_d N_d < k_a N_a$, the re-frozen layer will be p-type, and an n-p junction is formed at x_1. After the bar has solidified up to the ordinate at x_2 the bar is quenched. It cools so quickly that the impurity concentration in the liquid is frozen into the solid without change. Now if the volume of the bar between x_1 and x_2 is small compared with the total volume melted, the impurity concentration in the solid to the right of x_2 will be practically the same as before melting, N_d and N_a. Hence a p-n junction is formed at x_2. The width of the base layer between the two junctions at x_1 and x_2 is controlled only by the time of freezing before quenching,

hence the desired base and emitter resistivities can be controlled by choosing impurities with suitable k_s and k_d, and by using appropriate starting concentrations N_s, N_d. By this technique, transistors have been made with base thicknesses from about 2 to 25 microns.

Diffused base transistors

It is possible to shorten the transit time of the carriers across the base of a transistor, not only by decreasing the base width, but also by building into the base region an inherent electric field, so that the diffusion of the carriers across the base is aided by drift in the field. Suppose the concentration of donors in the n-type base of a p-n-p transistor varies as shown in Fig. 12. Then assuming that all the donors are ionized, the concentration of majority electrons is the same. The electrons will tend to diffuse to the right, since a concentration gradient exists. As soon as this occurs, an electrostatic restoring force is set up between the diffusing electrons and the fixed donors. It is clear that in equilibrium sufficient diffusion will have taken place to set up a field just strong enough to prevent further diffusion. This field will act toward the right in the figure, hence holes, emitted from the left into the base region, will drift toward the right in the field. If the base is p-type, then for the same configuration of acceptors as for donors, the field will act toward the left, since it must prevent the majority carriers, which are now holes, from diffusing to the right. The field will thus assist the passage of the minority carriers, electrons, from left to right across the base.

The requirement is, then, to fabricate transistors with a varying concentration of impurities in the base, high at the emitter and low at the collector. Kroemer[14] has shown that if the concentration varies exponentially then the field in the base is uniform, and that the transit time may be (theoretically) about ⅛ of that in a uniformly doped base of the same thickness.

One method of producing a variation in impurity concentration similar to the above is by the diffusion of the impurity into the solid semiconductor[15]. (This is quite distinct from the "fusion" or "alloy" process in which the impurity metal is melted in contact with the semiconductor, so dissolving it and forming an alloy with it.) The diffusion source can be the vapor of the required impurity, or the vapor of the oxide of the impurity. Such vapor may be carried over the specimen in a carrier gas in an open tube, or may fill a sealed tube containing the specimen. A convenient method is to paint on to the semiconductor a suspension of the impurity oxide in a volatile liquid such as ether. The diffusions are carried out at temperatures of 700-800 C for germanium and 1,100-1,200 C for silicon. By these means, an n-type skin may be diffused onto a slice of p-type semiconductor. The n skin may be considered the base of a p-n-p transistor, and the original p-material, the collector. The diffusion process is slow; for instance it takes approximately five hours at 1,100 C to diffuse phosphorus into 20 ohm cm p-type silicon so as to produce an n-layer five microns thick, hence control is very good. An emitter may be made on the thin base by diffusion of an acceptor impurity, in which case its concentration at the surface of the semiconductor must be greater than that of the first impurity so as to convert the conductivity type. Alternatively, the emitter can be alloyed in. Figs. 13 and 14 show the impurity distributions for a p-n-p transistor made by these two methods. Tannenbaum and Thomas[16] have described a silicon n-p-n transistor made by diffusion in which the acceptor impurity used diffused faster at a given temperature than the donor impurity, so that n-p-n structures were made with a simultaneous diffusion of both impurities. It was found possible to make base layers two microns thick with a thickness

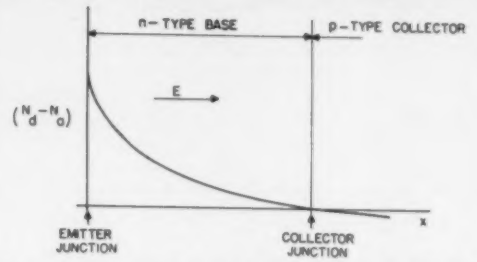


Fig. 12. Concentration of donors in base of diffused-base transistor. Field E assists passage of minority carriers across base

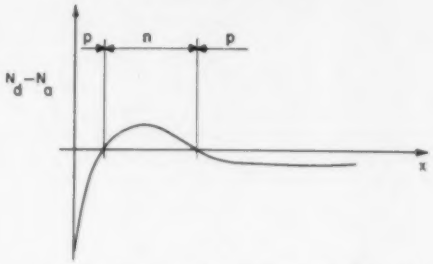


Fig. 13. Impurity distribution in diffused-base, diffused-emitter p-n-p transistor

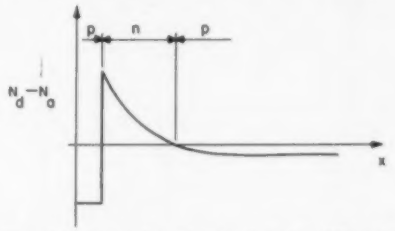


Fig. 14. Impurity distribution in diffused-base, alloyed-emitter p-n-p transistor

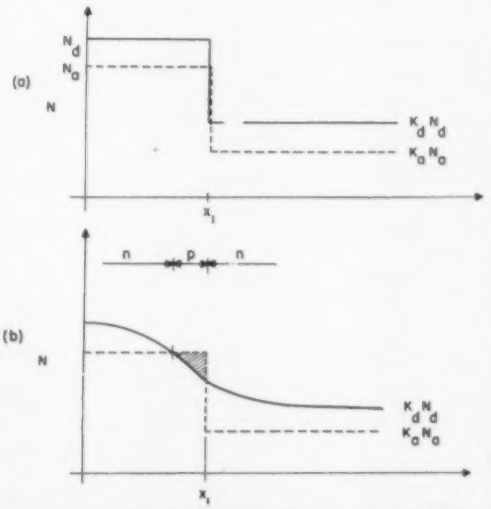


Fig. 15. Impurity distribution (a) before and (b) after diffusion in construction of n-p-n structure by "surface-melt and diffusion"

variation of less than 10%. These transistors have had alpha cut-off frequencies greater than 100 mc. Lee[17] has reported diffused base, alloyed emitter, p-n-p germanium transistors with base widths of 1½ microns and alpha cut-off frequencies of about 500 mc.

It is interesting to note that with these very thin base devices, the carrier transit time through the collector junction depletion layer is no longer negligible compared with the base transit time. Lee, in the reference cited, estimates that the collector depletion layer is about four microns thick with 10v bias, and that the cut-off associated with this layer is about 3,000 mc. He also estimates that the enhancement of the cut-off frequency by the built-in field is at the most a factor of two. As remarked above, the rate grown transistor has a varying impurity concentration in the base. This is such as to give an electric field which aids the transport of minority carriers.

Another method for making thin base layers of graded impurity concentration is called "surface melt and diffusion" by Lehovec and Levitas[18]. A crystal is grown doped with both donor and acceptor impurity concentrations N_a and N_s, so that the crystal is n-type. The crystal is melted back to the ordinate x_1 in Fig. 15(a) and recrystallized. The concentration of the impurities to the right of x_1 will now be k_dN_d and k_sN_s as discussed in the "melt quench" case. Let $k_dN_d > k_sN_s$ so that the crystal is still n-type. Now the temperature is raised to just below the melting point, and diffusion of the impurities takes place across the ordinate x_1. Suppose the donor impurity diffuses faster than the acceptor. Then for a diffusion time which will result in little change in the concentration of the acceptors, an appreciable proportion of the donors will diffuse to the right of x_1. With proper selection of the impurities, starting concentrations, and diffusion time, a p-type layer is formed which may be only a few microns thick, Fig. 15(b). For the same conditions of diffusion rates, it is possible to make p-n-p structures if we have $N_s > N_d$ and $k_sN_s > k_dN_d$ for the impurity concentrations to the left and right of x_1.

For the commonly used impurities, donors do diffuse faster than acceptors in germanium. In silicon the reverse is the case, i.e., acceptors diffuse faster than donors. The structures p-n-p and n-p-n may be made in silicon by inverting the concentration inequalities for the cases n-p-n and p-n-p above, respectively.

Summary of "conventional" transistors

It is apparent from the above that several fabrication methods are capable of producing structures which will amplify at frequencies of from 100 mc upward and will oscillate at very much higher frequencies. To summarize, these methods are:

A	B
Rate Grown	Surface-Barrier Transistor
Melt Quench	p-n-i-p
Surface Melt	Diffused Base
and Diffusion	(i) with diffused emitter
	(ii) with alloyed emitter

The methods in group A will most probably lead to bar-type devices as shown in Fig. 2. In view of the need to reduce the active area of the emitter in the bar-type devices as previously discussed, these transistors would probably be tetrodes for the highest frequency operation. The two diffused base structures in group B would have a geometry similar to the p-n-i-p (Fig. 4), but where the "i" layer is p-type and serves directly as the collector.

Potential for further development and ease of construction are two important factors to be considered. Regarding the former, probably all the methods in groups A and B above, except the surface-barrier transistor, are capable of producing base layers down to one micron thick and perhaps even less, with a possible superiority in the diffusion methods at these base widths. Ease of construction is another matter. For tetrodes, a connection has to be made to the edge of a layer which is less than a few microns thick. Since the wire used will be greater than this in diameter, distortion of one of the junctions will result. The contacts involved in the p-n-i-p and diffused base structures in group B are to areas of perhaps one by two thousandths of an inch[17]. These contacts can be bonded wires, and are probably easier to make than the tetrode base contacts.

Now that diffusion techniques can be realized to put very thin and highly doped n-skins on (say) intrinsic wafers, and since there exist alloying techniques for making p-n junctions within the depth of such layers, it is possible that the p-n-i-p holds the greatest promise of the above structures for the reasons discussed earlier.

J. R. A. Beale[19] has reported a method of construction of a diffused base device whereby the diffused base and alloyed emitter are formed in one operation in material which serves as the collector body. The control of this process is probably at least as good as in other diffusion processes, and it has the great merit that a ready-made emitter metallic contact is produced at the same time. Experimental devices have had alpha cut-off frequencies of about 200-300 mc.

Philco have announced two more high-frequency transistors, the micro-alloy transistor and the micro-alloy-diffused transistor. The first is believed to be of the same construction as the surface-barrier transistor except that it has alloyed junctions instead of plated contacts. The constructional details of the second have not been published.*

"HIGH CARRIER VELOCITY" TRANSISTORS

We shall now describe the second broad class of high frequency transistors, namely, the high-carrier-velocity types occupying the right-hand side of the flow chart of Fig. 1. These devices depend for their short transit time on high electric fields giving high carrier velocities. Although none of the devices to be described are as yet commercially available, it would appear at present that this approach holds the greatest promise of producing a true "microwave" transistor. However, before proceeding with a discussion of practical approaches to this problem, it might be of historical interest to discuss briefly the "analogue transistor" as proposed by William Shockley in 1952[20]. This device is of academic, rather than practical interest, since it has never actually been constructed in the originally envisioned form, but it does provide a convenient introduction to the devices to be described later.

The analogue transistor

As was pointed out by Shockley, a number of analogies may be drawn between semiconductor electronics and conventional vacuum tube electronics. For example, a perfect single crystal of a semiconductor, containing no lattice defects or impurities, might be thought as the analogue of the vacuum existing within a vacuum tube. It is true that such a crystal will not have zero electrical conductivity (as would a perfect vacuum) owing to the thermally generated carriers at all temperatures above absolute zero, but in general the resistivity of such a pure "intrinsic" semiconductor will be quite high compared with that of the impurity-bearing material used in most devices. To

**Since the above was written, details of these structures have been announced by Rittmann et al in the I.R.E. Transactions on Electron Devices, ED5, p. 49, April 1958; and by Thornton and Angell in Proc. I.R.E., 46, p. 1166, June 1958.*

carry the analogy further, the electrons emitted by a hot filament in the vacuum might be compared with carriers injected into the intrinsic semiconductor by a neighboring n- or p-type region, or by a point contact. Fig. 16 shows the analogy extended to a vacuum diode, with its semiconductor counterpart. The latter might be called a "unipolar" semiconductor diode, the term "unipolar" being used to distinguish devices whose operation involves the flow of one type of carrier only, as opposed to "bipolar" devices where conduction by both types of carriers, holes and electrons, takes place simultaneously. All vacuum tubes are unipolar devices, whereas conventional semiconductor diodes and transistors are bipolar.

The unipolar diode shown in Fig. 16 obviously has no rectifying properties because of its symmetry, and is therefore of little practical value. It does, however, raise an interesting possibility. Under certain conditions, the flow of electrons through the intrinsic region is found to be space-charge limited, with the current density under such conditions given by the expression under the diagram. Note that this equation is the semiconductor analogue to Child's law which applies to space-charge limited current in a vacuum diode. The next step in the analogy is now obvious. Just as a grid may be placed in the space-charge region of a vacuum diode to modify the effect of the space-charge and thus exert control over the anode current, so it should be possible, Shockley suggested, to create an amplifying structure from the semiconductor unipolar diode by the addition of an analogue "grid." Fig. 17 shows a schematic diagram of such an analogue transistor, the grid being provided by a series of p-type rods. The polarity of the grid bias is such as to increase the potential barrier to the flow of electrons injected into the intrinsic region by the "cathode." Thus very little grid current flows and input impedance is high. Because of the high input impedance of this and subsequently described devices, it is usual to discuss amplification in terms of transconductance g_m, as is done in the case of vacuum tubes, rather than in terms of alpha as is done for conventional transistors. The chief advantage of a device such as this is that the current carriers drift in a region of high electric field, and hence for comparable size of structures the transit time will be greatly reduced with a consequent improvement in frequency response.

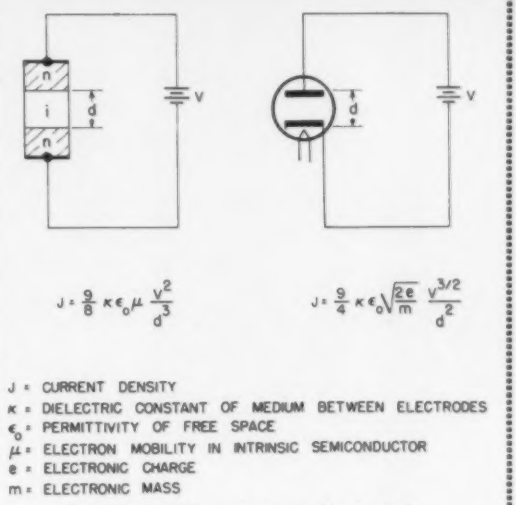


Fig. 16. Analogy between "unipolar" semiconductor diode and vacuum diode

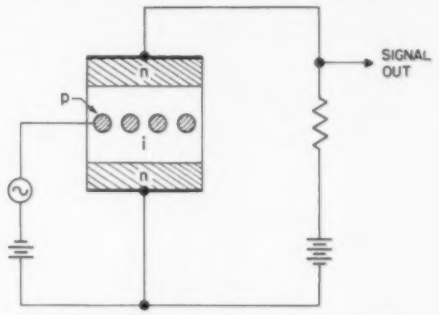


Fig. 17. Shockley's "analogue transistor"

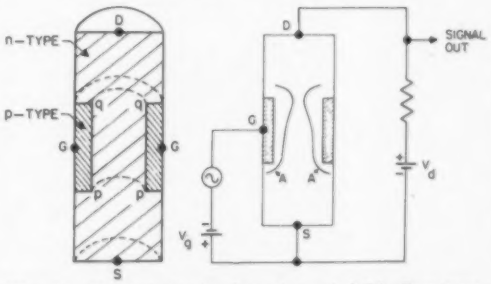


Fig. 18. (L) Longitudinal section of field-effect transistor. p-q are the exposed p-n junctions formed by the ring of p-material around the n-type bar

Fig. 19. (R) Possible circuit configuration for field-effect transistor. The lines A represent boundary of depletion layer formed by reverse biased p-n junction

Field effect transistor

As noted earlier, the analogue transistor has never been constructed due to practical limitations. The theory of a device somewhat similar in principle called the field effect transistor, was given by Shockley about the same time. This device had the advantage of being more amenable to fabrication by existing techniques, and Dacey and Ross in 1953[21] announced results gained with experimental devices, and in 1955[22] they extended the theory.†

The field effect transistor is essentially a semiconductor whose conductance can be modulated. A bar of n-type semiconductor has two p-type regions G, as shown in Fig. 18, so that the conducting n-type path S-D is bounded by the two p-n junctions pq. If now the two regions G are connected to the end S of the bar and a voltage V_D applied across the bar such that the end D is positive with respect to S, then electrons will flow from S (the "source") to D (the "drain"). Consequently, the potential in the channel will increase toward the drain. Since the regions G are connected to the source, the potential rise in the channel results in an increasing reverse bias across the junctions toward the drain. The depletion layer associated with a p-n junction increases in width for increasing reverse bias, hence the depletion layers penetrating into the conducting channel will become wider along the bar. (The term "depletion layer" is used here in place of the more common expression "space charge region" in order to avoid con-

†*Details have been published recently in L'Onde Electrique of a field effect transistor developed in France, called the "Technetron." It differs from the device to be described here chiefly in its cylindrical rather than rectangular geometry, and its novel fabrication technique. A short note on the construction of this device appears in Wireless World, Feb. 1958, p. 82.*

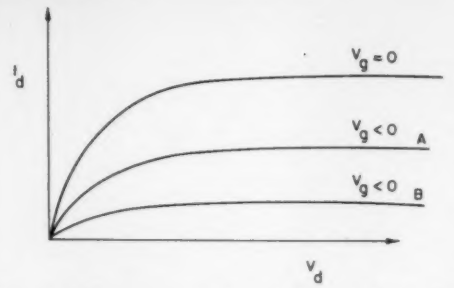


Fig. 20. Voltage-current characteristics of field-effect transistor with Vg as parameter. For curves A and B, Vg is becoming more negative

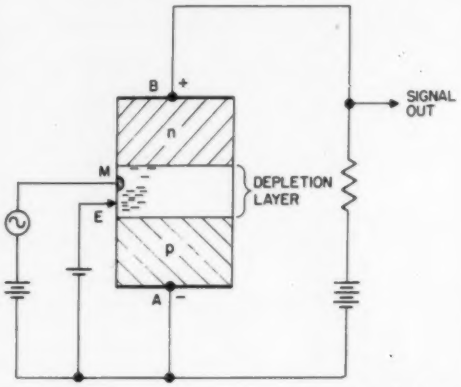


Fig. 21. Spacistor triode in possible amplifying circuit

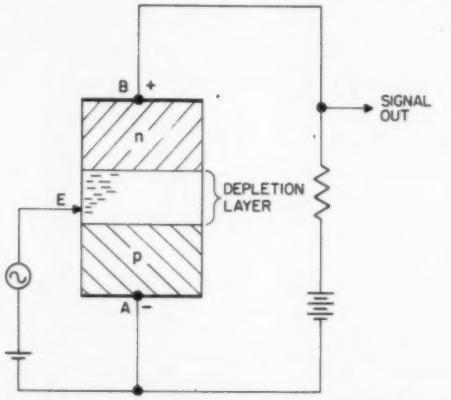


Fig. 22. Spacistor tetrode. Although E is shown positive with respect to A, it is still negative with respect to underlying region. M is biased so as to draw very little current.

fusion with "space-charge" limited emission, referred to later.) The field in these regions is such as to confine the electrons flowing in the bar to the channel between the depletion layers, and so the channel narrows as the drain is reached. As the drain voltage is increased, so is the drain current, increasing the reverse bias across the junctions and the widths of the depletion layers. At a particular value of VD dependent on the resistivity of the channel and the separation of the two junctions, the depletion layers meet. The current is then substantially constant for further increases of VD. This is known as the "pinch-off" condition. For reasons which will be evident, the regions G are called the "gates."

If a voltage VG is applied between the gate and the source, Fig. 19, so that the gate junction is reversed biased, then current saturation at pinch-off will occur for lower values of drain current and voltage, and so the drain characteristics will be as shown in Fig. 20, where VG is a parameter. It is evident that if VG is modulated by a signal, then the drain current ID is likewise modulated. These characteristics resemble those of a pentode tube, and the device can be used to amplify in a manner similar to a pentode.

A field effect transistor should work at higher frequencies than a junction transistor of comparable dimensions, for the current in the field effect device consists of majority carriers drifting in an electric field, instead of minority carriers diffusing in a region effectively field free as in a junction transistor. Since drift velocities can be higher than diffusion velocities, transit times for the field effect device can be shorter than for the conventional transistor.

If the reverse biased gate junction saturates well, the only current of signal frequency in the input circuit is that required to charge the gate junction capacitance as the depletion layer widens. This capacitance could be less than a few uuf, so the input impedance of this device will be very high at low frequencies.

Dacey and Ross show that a reasonable theoretical upper limit to the frequency cut-off of a device made from n-type germanium is 1,000 mc. The separation between the junctions is 6 microns and so is the length of the channel. The highest cut-off frequency they obtained using indium alloyed into the germanium for the gates was about 50 mc.

The spacistor class

While the field effect transistor has been successful in achieving short transit times through the use of high electric fields, the maximum field in the channel is limited by the heat generated by the current producing that field. In the devices to be described next, fields are employed which are orders of magnitude higher than those obtained in the field effect transistor, without the problem of heating. This is accomplished by utilizing the extremely high electric fields existing in the depletion layer of a reverse biased p-n junction. The first experimental devices employing this principle to be reported were the spacistor triode and the depletion layer transistor. These devices have certain limitations which may be largely overcome by the use of a second contact in the depletion layer. Therefore only a brief description of these two devices will be given, mainly to serve as an introduction to the more promising spacistor tetrode to be treated in greater detail later.

Spacistor triode

In the spacistor triode[23] shown in Fig. 21 a p-n junction is biased in reverse creating a depletion layer which may be of the order of .001 inches wide. A small contact E is placed in this region and biased so as to emit electrons. Amplification from these devices depends on multiplication of these carriers by an avalanche process due to the high electric field in the depletion layer. A disadvantage of such a device is the difficulty in placing the emitter contact, which must be an alloyed p-type dot, in the narrow depletion layer. A more practical form would be a structure similar to that of a conventional p-n-p junction transistor. If the collector is biased sufficiently high in the reverse direction with respect to the base, then the collector-base depletion layer extends up to the emitter junction. This causes what is known as "electrical punch through," and the suitably biased emitter now performs the function of the emitter point in Fig. 21, and injects carriers into the collector depletion layer. The difficulty encountered

with this device is that the avalanche-produced carriers tend to accumulate in front of the emitting contact, resulting in relaxation-type oscillations when this contact is biased with a high series resistance. This trouble might be eliminated by making the emitter very small, or alternatively by the use of a magnetic field.

Depletion layer transistor

The depletion-layer transistor described by Gaertner[24] is similar in principle to the spacistor in that both employ the injection of carriers into the high electric field of a reverse biased p-n junction. This device, however, does not employ carrier multiplication by the avalanche process, and hence is not bothered by accumulation of carriers. It depends for its operation on the emitter contact being very close to the boundary between the depletion layer and the p-type region. The position of this boundary depends critically on the potential across the junction and also on the electron emission from the emitter, and its mechanical construction and operating conditions are therefore very critical. It has been predicted that under optimum conditions devices of this type might provide power gains of 10 db at 1,000 mc.

Spacistor tetrode

The most recent development in high field devices is the spacistor tetrode, first announced by Statz et al in 1957[25]. A schematic diagram of such a device and an illustration of how it might be arranged in an amplifying circuit are shown in Fig. 22. As in the preceding devices, a reverse biased p-n junction is used to provide a high electric field. An emitter contact E consisting of a tungsten point is placed in the depletion layer adjacent to the p region. This contact is biased slightly negative with respect to the underlying depletion layer (although still positive with respect to A) and consequently injects electrons which drift toward the n-region. As in the case of the unipolar diode described in a previous section, this emission of electrons is space-charge limited. A second contact M, known as a modulator, is now placed in the depletion layer between the emitter and the n-type region. This contact consists of a small alloyed p-type dot, and is reverse biased with respect to the underlying region, consequently drawing little current and providing a high impedance circuit. Small changes in potential of this modulator contact will alter the electron space charge of the emitter, and hence exert control over the emitter current. Thus it may be seen that amplification is possible with this device in a manner quite similar to the operation of a vacuum tube. The emitter E is equivalent to the vacuum tube cathode, the modulator M corresponds to the grid, and the n-region at B to the plate.

A second function of M is to reduce the influence of voltage changes across the load on the emission of E. The result is that the emitted current is almost independent of the voltage across AB, and hence the dynamic output impedance will also be very high. In a typical device constructed of germanium, these impedances are both of the order of 30 megohms, and in similar silicon devices this figure will be very much higher. Input and output are loosely coupled through small interelectrode capacitances (of the order of 1 or 2 uuf) and therefore the device is suitable for cascaded multistage amplifiers.

The transconductance g_m of such a device may be defined as

$$g_m = \frac{\partial I_{out}}{\partial V_{in}} = \frac{\partial I_{inj}}{\partial V_{mod}}$$

and theoretical considerations show that values from 100 to 1,000 micromhos should be obtainable, depending on geometry. This corresponds to voltage gains of 3,000 to 30,000 for a matched output load resistance of 30 megohms. This load impedance may not be practical at audio frequencies, but at radio frequencies a high Q tuned circuit may be used. Gain will fall off when the frequency approaches the reciprocal of the transit time, but with further development the spacistor would appear capable of providing substantial gains up to possibly the kilomegacycle range.

Another interesting feature of this device is that the minority carrier lifetime can be neglected owing to the extremely short transit time. It may therefore be possible to utilize semiconductors having special properties whose use in conventional devices may be prohibited by short lifetime. For example, indium antimonide with its high electron mobility (20 times that of germanium) may be used to extend the frequency range still further in spite of its lifetime of about one microsecond. Also, high energy gap materials such as silicon carbide might be used to produce transistors capable of operation at temperatures approaching a red heat.

In conclusion, it should be noted again that the class of high carrier velocity devices just described are still in the experimental stage, and are not yet being produced commercially. At this time, it would appear that the best high frequency transistors readily available are those of the surface-barrier type, or devices employing modifications of this construction. The 108 mc transmitter of the U. S. Vanguard satellite is reported to use several surface-barrier transistors in the rf section. It would seem, however, that any great frequency improvements of "conventional" transistors will be met with rapidly increasing fabrication problems. This has been explained earlier in the summary of "conventional" devices. It is true that very severe difficulties also occur in the construction of the various high-field devices, but when an amount of development work has been carried out in this field equal to the amount done on conventional devices, it is felt that the former will prove far superior in high frequency response. END

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The introduction of reliable, wideband radio systems has made it possible for telephone companies to use radio carriers for regular network services to many individual communities. This involves some new techniques in high frequency bridging, branching and interconnecting of multichannel radio carrier systems

New techniques allow wider use of radio carrier in telephone systems

E. V. HIRD P.ENG.*

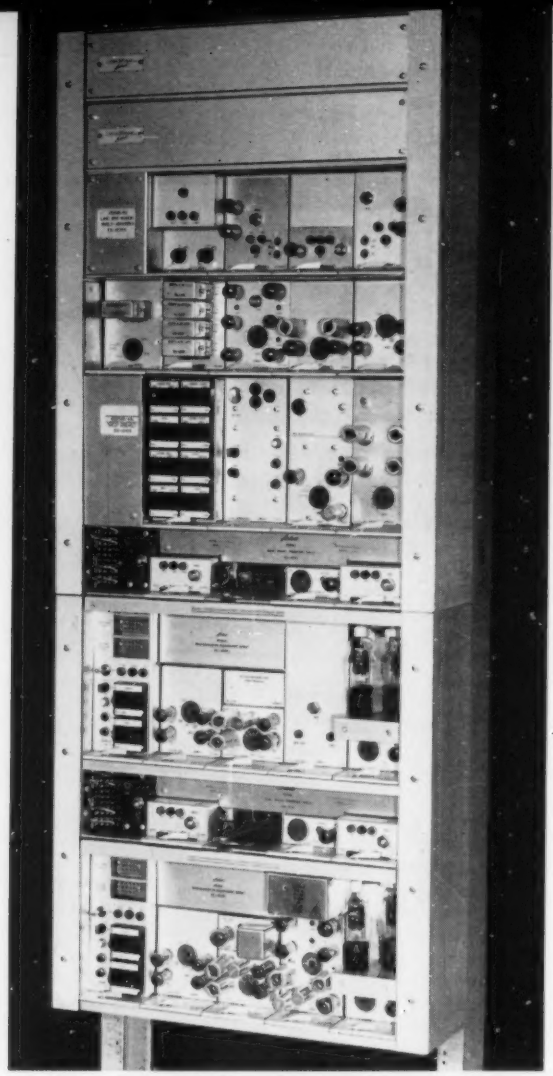


Fig. 1. 24 channel 45BX to 45A interconnect bay

Early applications of carrier equipment on narrow band radio systems were invariably on short haul, point-to-point circuits, with no dropping or branching of the carrier frequencies at intermediate radio repeater points. However, with the availability of reliable wideband radio systems, it has now become practical for communication companies to install one radio system to serve a network of separate communities, with certain channels being through connected, with others dropped off and separate channels reinserted into the radio baseband at radio repeater locations. Each repeater is generally composed of two terminals connected back-to-back via some form of baseband branching, bridging or interconnecting equipment. The first part of this article describes methods of branching and bridging carrier terminal equipment onto the radio baseband at these repeater points.

Similarly, most carrier systems until recently were designed for use on a particular transmission medium; i.e., open-wire, cable pairs, coaxial lines or radio. Where interconnections between transmission mediums were required, demodulation was necessary, and the transfer was effected at voice frequencies. In addition to the extra cost of providing the channelizing equipment, this transfer method introduced considerable degradation to the transferred circuits because of the characteristics of the channel band pass filters. The ability to effect transfers at carrier frequencies between carrier systems and to drop off groups of channels at intermediate locations along a route without demodulating all channels of a system to voice frequencies, offers a number of advantages and provides considerable flexibility in system planning. The second part of this article discusses several forms of carrier frequency interconnection.

*Lenkurt Electric Co. of Canada Ltd., Vancouver.

Methods of branching carrier terminals at a repeater

Fig. 2 illustrates the branching of carrier terminal equipment at a repeater point consisting of back-to-back radio terminals. The use of the junction hybrid panel, with an insertion loss of approximately 4 db, allows a sharing of the radio baseband by two locations. An example of this would be where a 24 channel 45BX Radio Carrier Terminal consisting of Group 1 (40-88 kc) and Group 2 (92-140 kc), each employing twelve channels, was located at point A. Both group 1 and group 2 frequencies appear at points B and C, but by arranging the carrier terminals to accept only the desired frequencies, a sharing of the basegroup is achieved. Junction hybrids are available with drop impedances of 75, 130 or 600 ohms,

frequency response ranging from 200 cps to 1.2 mc, and trans-hybrid losses of 40 db or greater.

Fig. 3 illustrates the splitting of two groups of carrier channels by use of carrier frequency separation filters. Line filters with frequency separation points in the carrier range are available, permitting a wide variety of such applications. Filter panels of 600, 130 or 75 ohm drop impedance with balanced or unbalanced high and low pass sections, have been developed. The advantages of using a filter in place of a hybrid include low insertion loss (usually less than 1 db) and the rejection of any unwanted harmonics, as might be generated in the lower frequency carrier equipment, which could conceivably beat with the higher frequency carrier channels. Choice of a suitable filter is dictated by the frequency band available at the crossover point; i.e., the range between the highest frequency to be dropped via the LP section and the lowest frequency to be passed through the HP section. This fact plus the desired rejection between the LP and HP sections determines the quality (and cost) of the filter. Another important factor is that the HP section of the filter must be substantially flat over the range of the carrier frequencies to be used. Line filters also allow carrier channels to be dropped and reinserted thus allowing a portion of a radio baseband to be split and so provide toll circuits in both directions from a radio repeater location.

Methods of bridging carrier terminals at repeaters

Fig. 4 illustrates a method of junctioning three radio terminals, and also bridging carrier equipment onto the radio baseband. This application would occur where a spur line was required from the main radio system, and is particularly suited for party-line operation of carrier channels such as when utilized for dispatchers or order wire circuits. The four-wire four-way bridge has an insertion loss of 15 db, and will operate substantially flat from 300 cps to 1.2 mc with a hybrid balance of at least 50 db. Matching transformers allow its use with 600, 130 or 75 ohm radio baseband impedances with balanced inputs and outputs as required. If the north radio terminal was not required the unused access of the bridge would be terminated by two resistances.

Fig. 5A illustrates a method of bridging carrier equipment at a heterodyne repeater equipped with baseband modulators and demodulators. A junction hybrid panel allows the carrier frequencies to be party-lined in two directions. If party-line application is not required, the hybrid may be omitted and the carrier equipment may be connected to the east or west baseband accesses as required. Fig. 5B illustrates a similar type repeater with the exception that a mixing baseband amplifier is supplied to allow the carrier frequencies to be party-lined in two directions.

Dropping and inserting 24-channel groups at repeaters

Fig. 6 is a composite schematic illustrating methods of dropping, inserting and bypassing Type 45BX carrier channels at a repeater point utilizing back-to-back radio terminals. Shown are four separate methods of overcoming the problem of how to preserve high quality yet economically transfer the dropped channels from the radio repeater or terminal site to a toll centre or T & R room some distance away. In the illustration, the baseband input and outputs of the east and west radio terminals are each connected to an "R Group" junction filter used to separate a 120-channel group of toll circuits into five 24-channel groups, designated RA to RE. An optional 8-kc high pass filter may be inserted into the output of each radio receiver to block frequencies below 8 kc. The latter frequencies also appear in the service channel and may be used for transmission of fault alarm tones, pilot tones, plus order wire or service channel audio frequencies. The individual 24-channel bands are termed "line groups," with each group independent of the others.

The RE line group in Fig. 6 is transferred through to the east radio terminal at carrier frequencies, with the 428-528 kc band being demodulated in a group modem panel to the 40-140 kc (XA) range, passed through

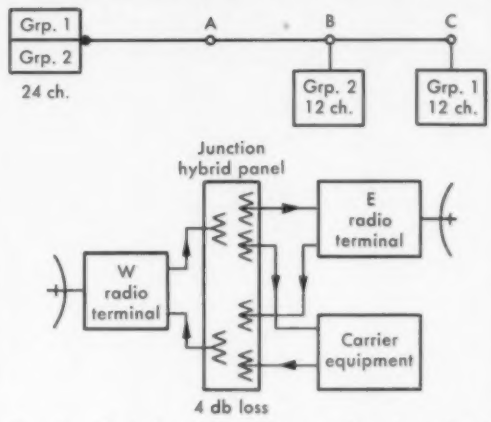


Fig. 2. Method of branching carrier channels at a repeater point by use of a junction hybrid

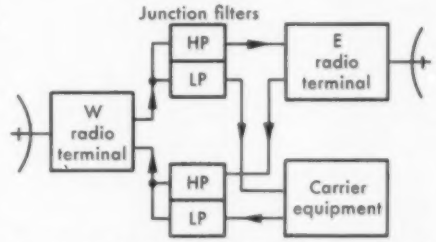


Fig. 3. Method of branching carrier channels at a repeater point by use of junction filters.

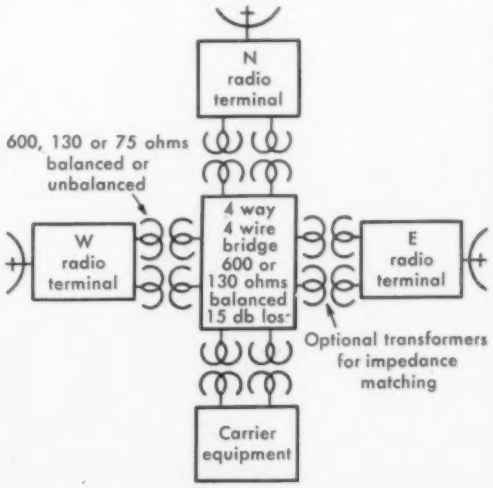


Fig. 4. Method of party line bridging of carrier channels at repeater point with 4-way 4-wire bridge

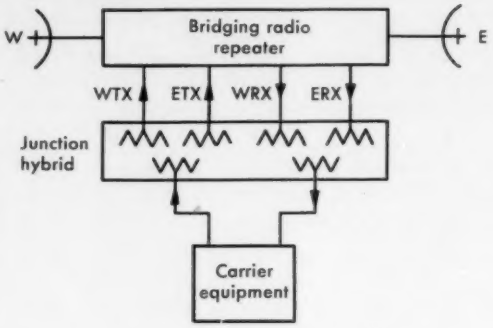


Fig. 5A.

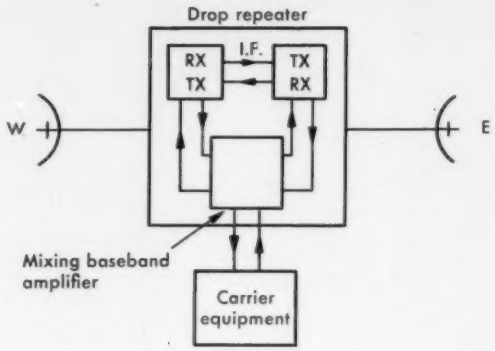


Fig. 5B.

Methods of bridging carrier channels at bridging or drop radio repeaters for 2-way party line operation

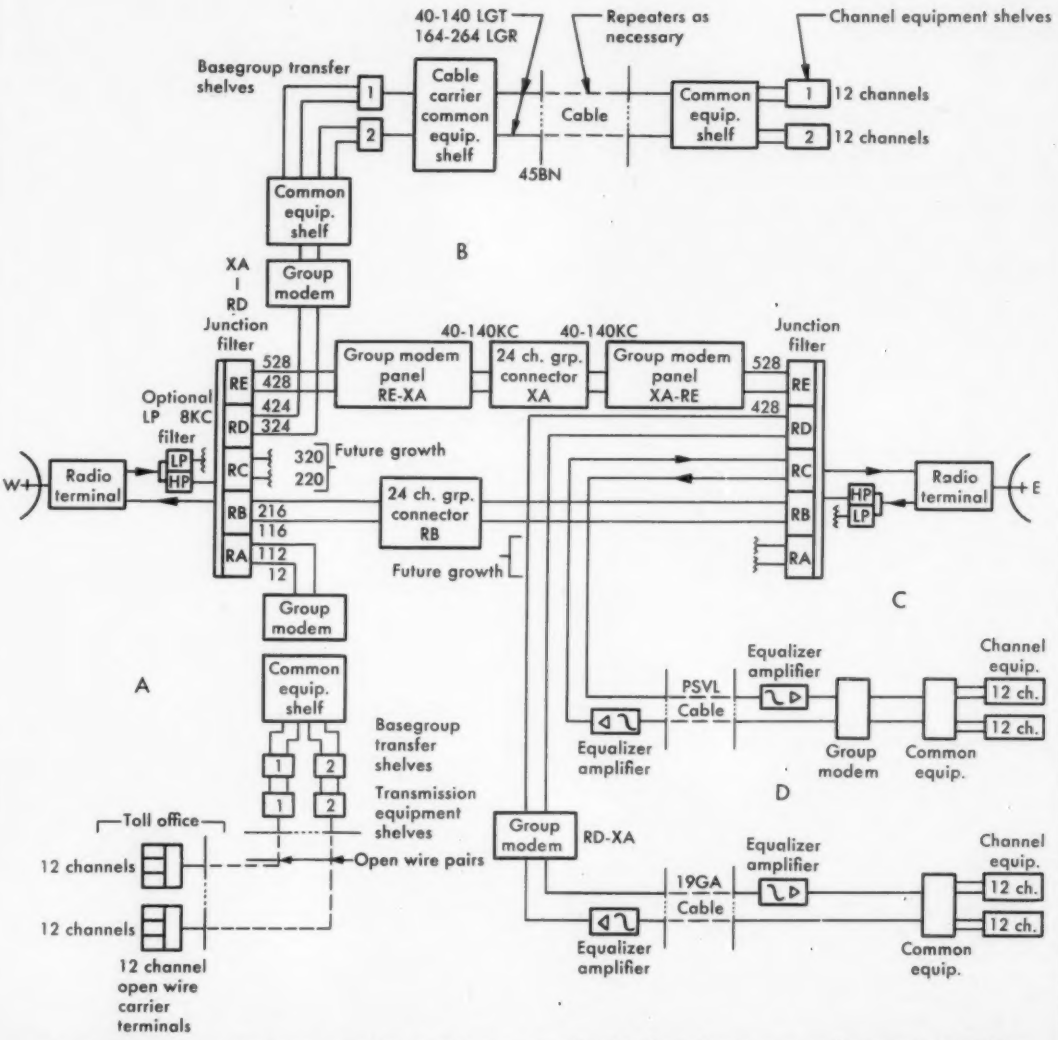


Fig. 6. Methods of dropping, inserting and interconnecting 24 channel groups at radio repeater locations.

a 24-channel group connector panel, remodulated to the 428-528 kc band, and combined in the east "R Group" filter before entering the east radio transmitter. The 24-channel group connector panel shown in Fig. 7 contains the necessary equipment to transfer the h-f signals of one 24-channel line group in both directions of transmission. The equipment associated with each direction of transmission consists of an adjustable pad, a bandpass or lowpass filter of the proper frequency characteristics for the line group to be transferred, and a plug-in transistorized fixed gain amplifier. The filters in the panel provide 80 db rejection of unwanted frequencies with the 4 kc guard band separating the individual "R Group" allocations. The RB linegroup is similarly transferred through to the east radio equipment by a 24-channel group connector panel, with the difference that no stages of modulation and demodulation are required, as filters to separate the RA and RB linegroups are directly inserted into the group connector panels as required. An RC or RD linegroup transfer would require similar equipment to that shown for the RE linegroup.

A typical method of transferring a 24-channel group at carrier frequencies between a radio repeater or terminal and a toll office is shown in A of Fig. 6. The 24 channels in the frequency range of 12 to 112 kc are interconnected to two Type 45A twelve-channel wire-line carrier systems. The RA linegroup is first demodulated to a standard 40-140 kc basegroup by means of a group modern panel, then inserted into a common equipment shelf where it is divided into two 12-channel groups each in the range of 40-88 kc. Each 12-channel group is then connected to a basegroup transfer shelf for amplification, level control and impedance matching before being passed to a transmission equipment shelf. This shelf modulates the 40-88 kc to the frequency range occupied by Type 45A open wire carrier systems and also provides power amplification to the transmitting levels required by open wire carrier systems. Note that the four-wire transmitting and receiving carrier frequencies at the input to the transmission equipment shelf are connected to a two-wire system using 40-88 kc for transmission in one direction and approximately 100 to 148 kc (depending on open wire frequency allocation used) in the other direction. Fig. 1 illustrates the exact equipment required for a 45BX to two 45A carrier terminal interconnection with Fig. 8 illustrating one of the two 45A carrier terminals that would be required at the toll office to demodulate the carrier frequencies to voice channel frequencies.

A typical method of transferring a 24-channel group at carrier frequencies between a radio repeater or terminal and a toll office by means of using Type 45BN cable carrier equipment is shown in B of Fig. 6. The 24 channels in the RD allocation (324-424 kc) are demodulated to the standard 40-140 kc basegroup by a group modem panel, then inserted into a common equipment shelf to be divided into two 12-channel groups each in the range of 40-88 kc. Each 12-channel group is then connected to a basegroup transfer shelf for amplification, level control and impedance matching, before being passed to the common equipment shelf of the Type 45BN cable carrier system. This shelf provides amplification and also positions the transmitting and receiving carrier frequencies to those used in the cable carrier; i.e., 40-140 kc for LGT (low group transmitting) and 164-264 kc for HGT (high group transmitting) or vice versa depending whether the carrier terminal transmits high group or low group. Pole-mounted cable carrier repeaters may be installed at approximately seven mile intervals along the cable if required. A standard 45BN cable carrier terminal installed at the toll office demodulates the carrier frequencies to voice channel frequencies.

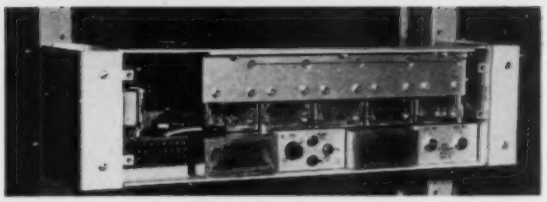


Fig. 7. 24 channel group connector panel with front cover off to show tandem filter connections and amplifiers

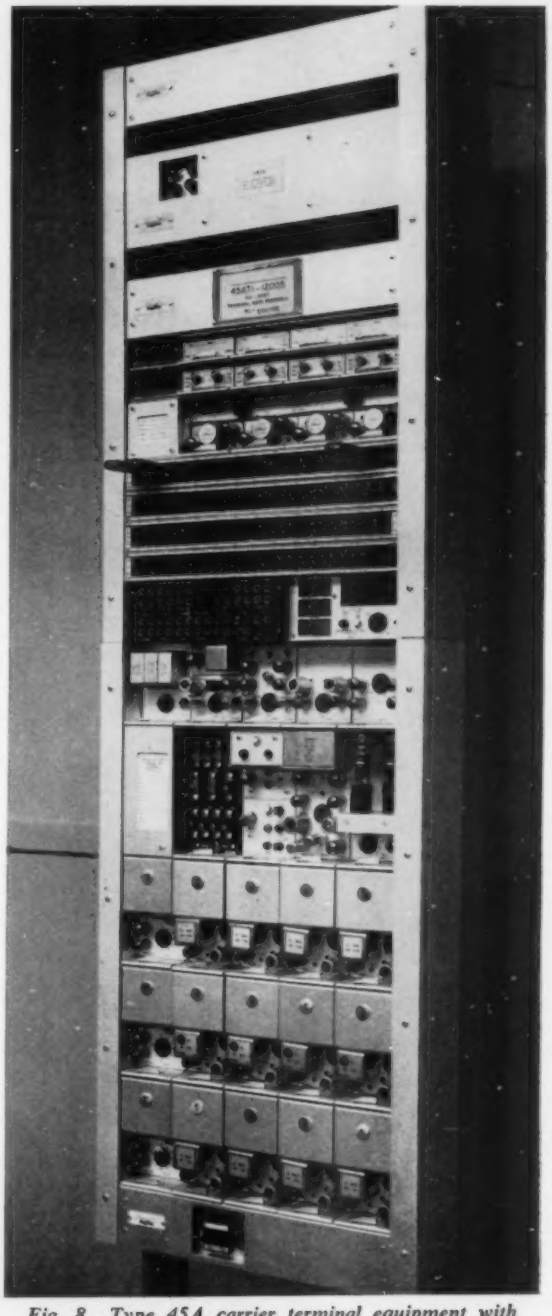


Fig. 8. Type 45A carrier terminal equipment with both a jackfield and a terminating test panel shown

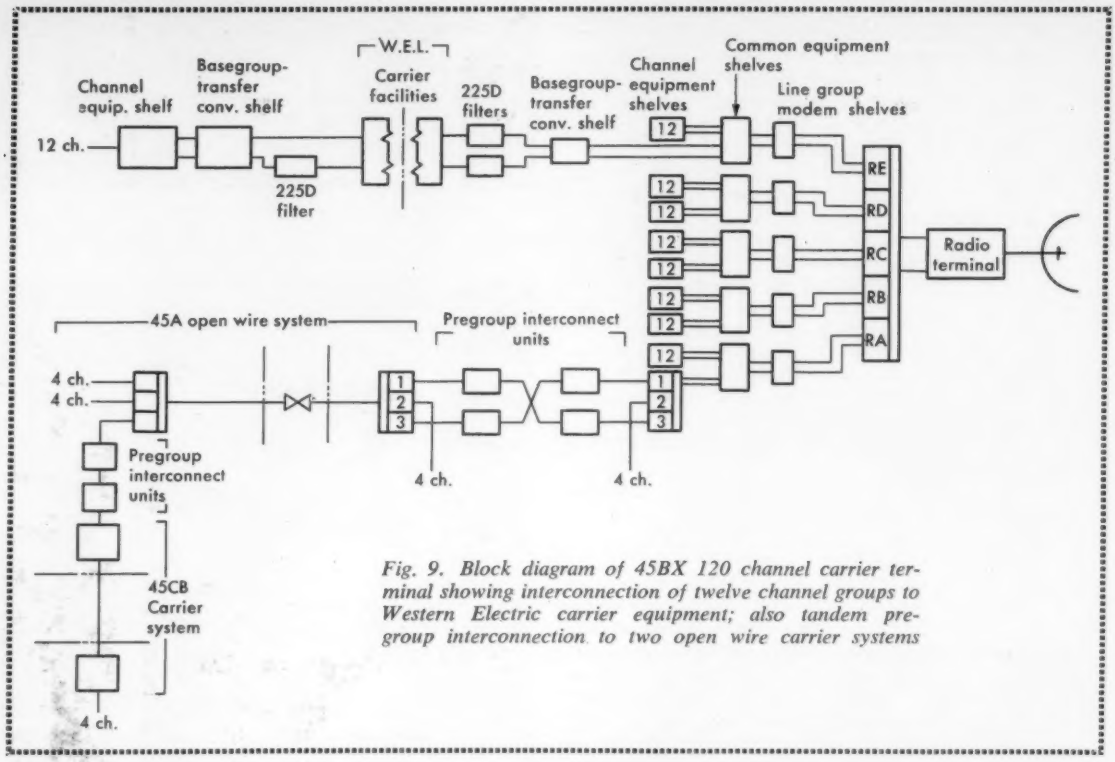


Fig. 9. Block diagram of 45BX 120 channel carrier terminal showing interconnection of twelve channel groups to Western Electric carrier equipment; also tandem pregroup interconnection to two open wire carrier systems

C and D of Fig. 6 illustrate two methods of transferring a 24-channel group at carrier frequencies between a radio repeater or terminal and a toll office by means of paired shielded video cable or 19-gauge toll cable. The 24-channel RC linegroup in the frequency range of 220-320 kc as shown in C of Fig. 6 is applied directly to cable such as 16 gauge PSVL. Equalizer-amplifiers, located in the receiving cable pair at the toll office and the radio site, equalize the slope in the cable and provide amplification for the carrier frequencies if required. A standard 45BX radio carrier terminal installed at the toll office demodulates the carrier frequencies to voice channel frequencies. A more conventional application for the PSVL cable would be at a terminal location, with 120 channels connected directly between the radio site and the toll office, utilizing the same wideband line equalizers and amplifiers. The 24-channel RD linegroup in the frequency range of 324-424 kc as shown in D of Fig. 5 is demodulated by a group modem panel to the standard 40-140 kc basegroup before being applied to 19-gauge toll cable. The loss in this frequency range is much lower than in the RC linegroup range. Equalizer-amplifiers, located in the receiving cable pair at the toll office and radio site, equalize the slope and provide any amplification required.

Pregroup interconnect

A pregroup interconnection transfers four channels of one pregroup between two carrier systems, without demodulation to voice frequencies. All pregroups of 45 class systems are positioned in the 8-24 kc range; thus to arrange a carrier terminal for pregroup interconnection, the four channel units of the specified pregroup are removed, and a pregroup interconnect unit provides impedance matching, level control, and what is most important, a very selective band pass filter in the range of 8-24 kc. This filter must provide an out-of-band rejection of at least 60 db within a 1-kc crossover range, both at 8 kc and

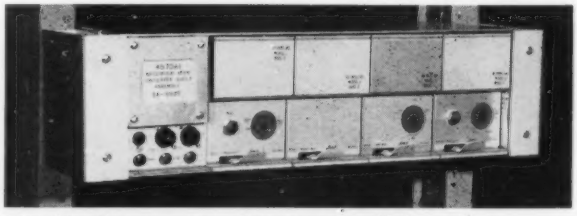


Fig. 10. Basegroup transfer converter shelf used to convert 40-88 kc basegroup to 60-108 kc basegroup

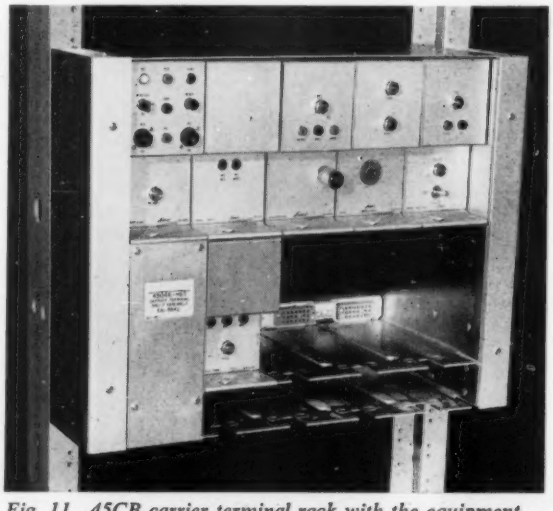


Fig. 11. 45CB carrier terminal rack with the equipment arranged for pregroup interconnect

at 24 kc. Due to the transmitting and receiving message level difference at the output of the pregroup unit (approximately 38 db) no amplification is required in the pregroup interconnect unit.

Fig. 9 illustrates the interconnection of two pregroups of a 45BX radio carrier system and a 45A open-wire carrier system. Four channels are shown as dropped in each direction. Note that pregroups 1 and 3 of the 45BX system are "frogged" to pregroup 3 and 1 respectively of the 45A system to provide additional rejection of any pregroup 2 frequencies which were not rejected by the pregroup interconnect filter, as the latter frequencies will appear out-of-band and will be further rejected by the carrier terminal directional filters. The 40 and 80 kc W-E pilots of the 45A system appear as 24 and 16 kc at pregroups 3 and 1 respectively, the E-W pilots appearing out-of-band with one exception in that the flat pilot appears at 8 kc for one frequency allocation (SA). A further interconnection of one pregroup of the distant 45A terminal to a 45CB four-channel open-wire carrier system allows the higher quality toll facility to be extended to a distant toll office. Fig. 10 illustrates a 45CB carrier terminal arranged for pregroup interconnect. All four plug-in channel units and compandors have been removed, with the pregroup interconnect unit plugged in channel 1 position.

Interconnection between different carrier systems

A requirement may exist for a group of toll circuits to be extended from a 45 class carrier system (40-88 kc basegroup) to another locality via a spare transmission facility available on Western Electric type J, K, or L carrier equipment (60-108 kc basegroup). Higher quality toll circuits may be obtained by means of high frequency basegroup interconnection between the two systems. A fully transistorized basegroup transfer converter shelf may be used to connect the 40-88 kc basegroup of 45 class systems to the 60-108 kc basegroup of Western Electric J, K, or L carrier system, and vice versa. The transfer converter shelf provides level co-ordination between the two systems as well as basegroup frequency inversion, where necessary, to always provide an inverted sideband to the Western Electric equipment. Fig. 9 illustrates an interconnection of Type 45BX and L carrier systems to extend twelve toll circuits to another location. Not that the basegroup transfer converter shelf serves as an interconnect unit at the radio location and distant terminal. In addition, it serves as a common equipment shelf at the latter location being connected directly to the channel equipment shelf. Western Electric Type 225D filters are used to suppress out-of-band frequencies between the two systems. Fig. 11 illustrates the basegroup transfer converter shelf. END

IRE technical sessions schedule

DATE and TIME	SESSIONS				
Wednesday, October 8 2.30 p.m. to 5.00 p.m.	ELECTRONICS FOR GUIDED MISSILES	INDUSTRIAL ELECTRONICS I	RELIABILITY REQUIREMENTS & ACHIEVEMENTS IN DESIGN AND PRODUCTION	BROADCAST & TRANSMISSION	PROPAGATION
Thursday, October 9 10.00 a.m. to 12.30 p.m.	AIRCRAFT ELECTRONICS	INDUSTRIAL ELECTRONICS II	EDUCATION	MEDICAL ELECTRONICS I	ANTENNA DESIGN
Thursday, October 9 2.30 p.m. to 5.00 p.m.	STEREOPHONIC DISC RECORDING & AUDIO	SEMICONDUCTOR THEORY AND MEASUREMENT	COMMUNICATION SYSTEMS	COSMIC RADIATION	AIRCRAFT THEORY
Friday, October 10 10.00 a.m. to 12.30 p.m.	TRANSISTOR CIRCUIT DESIGN	ASTRONAUTICS	ENGINEERING WRITING AND SPEECH	MEDICAL ELECTRONICS II	MICROWAVE THEORY & TECHNIQUES
Friday, October 10 2.30 p.m. to 5.00 p.m.	SEMICONDUCTOR APPLICATIONS	COMPUTERS	VEHICULAR COMMUNICATIONS	DESIGN TECHNIQUES	MICROWAVE SYSTEMS

See story on page 9

Lots of practice is needed to become a good speaker. Engineers at C.G.E. record speeches, then offer mutual criticism

Is your uhh.. IRE speech uhh.. ready?

HAROLD L. ARMSTRONG*

The 1958 IRE Canadian Convention will soon be here. Most of the technical papers will be well read, but a few may be deadly. To find out how Canadian General Electric Co. prepares its engineers, CEE called in, with a tape recorder, to get the story from H. L. Armstrong. His secret is to practise, practise, practise, practise, practise,

Our annual program for training the engineers who will be speaking at the I.R.E. Canadian convention is well established now. We have used it successfully for the past two years and consider the results well worth the time which is spent on the program.

As you know, summaries and abstracts of proposed technical papers are submitted in May. By the time we return from our annual plant vacation in early August the speakers for the technical sessions have been selected. We start right then on our training session. We devote one or two hours a week to develop confidence and ease on the platform so that the engineers can speak clearly and at the same time watch the audience.

First step is to record the voice

The first thing I do is take each engineer individually and have him make a recording of his voice on a tape recorder. It doesn't matter what he reads for this session. It could be some report he has just written, a few paragraphs from a book, or some other material with which he is fairly familiar. At this stage few of them have their actual I.R.E. papers completed.

After he has made the first recording I spend an hour with him going over the recording in detail. This gives him an opportunity to hear his voice as others will hear it and, believe me, it generally shocks him.

I point out the mistakes in enunciation, pronunciation, speed of reading, voice inflection, and so forth.

Talking on a subject with which he is familiar is advisable for the first few sessions. This helps to give him confidence and the first thing I want to get from the speaker is relaxation when he is on the platform.

After these preliminary rehearsals I have the engineers read their I.R.E. papers and make a recording of their speeches. They take these home so they can analyze their tone and expression, errors in grammatical construction and mispronunciation of words. I do not make any changes in their papers unless there are some words or expressions with which they have difficulty. Then I suggest they try to get other words that don't give them trouble but will convey the same sense.

Practise the steam-shovel method

Many of the engineers read their papers so we specialize in what we call the steam shovel method. These few paragraphs taken from my book "Effective Speech Presentation" will explain this technique.

"Here's how it works. You—at some time or another, have been a 'side-walk superintendent,' standing by the guard rail watching a steam shovel do its job of excavating a cellar or basement for a large building. You see the

*Canadian General Electric Co. Ltd., Toronto

The speaker must learn to face his audience at all times and not turn away when using charts, slides or other aids

operator as he manipulates levers and raises the shovel up in the air, swings it over to a spot in the excavation and drops it into the earth. As it drops, its huge jaws open up before they hit the earth and plunge deep into the ground. Then as the operator begins to raise the shovel, the jaws automatically close and the shovel fills with earth.

"Watch closely now to what happens next. The huge shovel full of earth seems to rise and face you then its tightened jaws are released and its load is dropped into a dump truck. The same performance is repeated time after time—gouging out the earth, raising and releasing its load. Remember it doesn't release the load until it has been raised up to a higher level.

"You say, 'How does this apply to reading a speech?' Well, the 'Steam-Shovel' method is just this simple. Glance at your manuscript, gather a few of the written phrases thereon, (just as the steam-shovel scoops up the earth); then raise your head—look at the audience and speak those phrases right at your listeners. When you have spoken them, look down again at your manuscript, gather a few more phrases, raise your head and speak what you have just picked up. Each time you lower your head to pick up more phrases be sure that you raise your head again and look at the audience before you speak—and keep looking at the audience until you have spoken every word before you look down again at your manuscript.

"At first it will be difficult and hard because you will only be able to pick up a few words at a time and you may become a bit embarrassed at the bobbing up and down so often. By practice you will speed up your silent reading and be able to grasp longer, or several phrases at a time. It will not be long before you have gained confidence in yourself and your reading will be easy."

Make use of visual aids

We have a number of projection machines available but we find the Reflectograph machine most convenient during the early stages of training. The first time the engineers deliver their I.R.E. papers they generally have rough sketches on paper. This makes it easy to make changes to correct or simplify the illustrations. Before the last practice session all illustrations are made in permanent form.

There are some other little dodges that are quite useful. When the engineers have their papers finished I get them to put oblique strokes on the paper at regular intervals. If they have not practised the steam-shovel method of delivery to the point where they can pick up the phrases or sentences instinctively then they can look for the oblique strokes to help them out.

Another thing I have them do is type their speeches double spaced with the important factors underlined so that they can put more emphasis on those words. Numbers are marked on the side of the manuscript to indicate when slides are due to come on and off. This makes it easy for them to have a free flow of continuity of thought and talk without stopping to ask the assistant to change the slides.

Practice is the key to success

The really important thing about this work is to get in enough practice so that the engineers are completely relaxed when they finally deliver their papers. They have about eight hours' practice to become acquainted with the steam-shovel method. Then, when their papers are completed they will have at least three rehearsals before audiences. The final rehearsal is held in our large auditorium at head office with as many people as we can get to form an audience.

At each one of these final rehearsals, every member who is in the audience is given a sheet on which he analyzes the speech and speaker for preparation, presentation, voice expression, gestures, attitude and the explanation of the material which is being presented. These sheets are then gathered together and given to the speakers so they can analyze themselves.

Besides all this I suggest that they read their papers at home in front of their wives or anybody else they can get to listen. They should practise the steam-shovel method at least ten or fifteen times between each rehearsal.

What you can do

Where the engineers don't have facilities such as ours I would offer these suggestions. They should write out their paper and then practise delivering it by the steam-shovel method. If possible, have some other person listen and offer criticism and they should also borrow a voice recording machine so that they can actually hear their own voice.

It is really amazing how a little practice will build up confidence, and confidence is certainly needed when you get up in front of a large audience. END

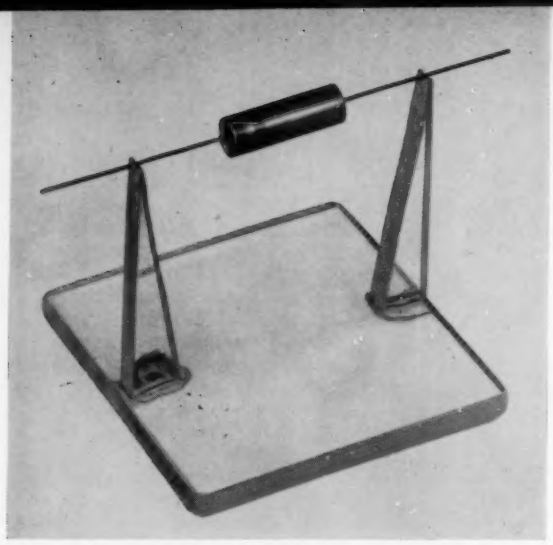


Fig. 1. Mounting fixture for measurement of rf coil SRF

SRF control makes rf coils versatile

The properties of a radio frequency coil at its self-resonant frequency increase its usefulness as a circuit element. Proper control of the factors, such as lead length, which determine the SRF is essential before these properties can be fully exploited.

J. P. BEVERLY, APPLICATION ENGINEER*

Today's continually increasing demands for circuit simplicity, reliability, and economy suggest a complete re-evaluation of the design potentialities for the simple rf coil.

All coils exhibit a self-resonant frequency (SRF) characteristic. The inductance of a coil, together with the inherent distributed capacitance in parallel, form a parallel tuned resonant circuit. The resulting characteristic may be utilized for many circuit functions.

However, proper control of the SRF characteristic and connected reactive circuit constants must be assured before the equipment manufacturer can fully exploit these circuit design potentialities. In recognition of this need, leading coil manufacturers stand ready to offer information on the SRF characteristics of their coils.

The significance of the major factors controlling SRF has prompted a thorough investigation of this important coil property at Jeffers Electronics Division, Speer Carbon Company.

SRF can be used in circuit design

For most general coil applications, the only requirement for SRF is that it be considerably above the operating frequency. This assures uniform circuit impedance. A specified SRF minimum is an accurate and convenient method of specifying the distributed capacitance of a coil. Any further requirements on this parameter for general applications could result in unnecessary restrictions on the coil design, which might add to the cost.

Although a coil possesses both inductance and inherent distributed capacitance, the reactance of these at SRF completely cancel out, thereby providing a resistive impedance. Such a resistive impedance is useful in many circuits wherever a large matching or blocking impedance is required providing other reactive circuit elements have been balanced or compensated for.

A coil operating at its SRF can be very useful in filter applications. A single coil connected in series will serve as a band-stop filter. Similarly, a single coil connected in parallel will serve as a simple band-pass filter.

A coil functioning at its SRF can also serve as a "stand off" terminal mount. Such "mounts" offer impedance at a particular frequency comparable to that of a good quality insulator. Other frequencies and dc current are readily passed.

SRF must be measured carefully

It is difficult to over-emphasize the importance of good measurement techniques in any program of close SRF control. For small rf solenoid coils with axial leads from 0 to 0.5 in. long and with inductance values up to a few microhenries, a typical distributed capacitance would be 0.3 micromicrofarads.

However, this does not mean that accurate measurement is not readily possible. With a properly calibrated stable grid-dip meter and proper coil mounting fixture, readings can be made in a matter of seconds on a production basis. A proper holding fixture can be of any design that adds a minimum of capacity to the coil. Accuracy of measurement is usually limited only by the readability of the meter scale.

A proper mounting fixture may consist of two upright supports of polystyrene extending at least 2½ in. from a base as shown in Fig. 1. The supports should be tapered to a knife edge at the top and should be arranged so that the coil can be supported with a lead on either knife edge. Grid-dip meter readings of SRF should then be taken with a minimum of inductive coupling, Fig. 2.

The lead length of the coil is a very important factor in any accurate determination of the SRF of a coil. For this reason, it is necessary either to make all such measurements with the same lead length for each coil type or to apply a suitable correction factor.

Factors influencing SRF

The SRF characteristic of a small rf solenoid coil and the factors affecting it are well defined mathematically. Since the constants of a coil form a parallel tuned resonant circuit, SRF is given by the following formula:

$$SRF = 159.2/\sqrt{LC} \qquad (1)$$

Where SRF is in megacycles
C is in micromicrofarads (at SRF)
L is in microhenries (at SRF)

The inductance of a coil can be readily determined; the distributed capacitance of the coil is less obvious. For coils on forms with axial leads, the C is made up of the following factors:

1. Capacitance due to the coil form;
2. Capacitance due to coil form leads;
3. Capacitance between the turns in the coil winding;
4. Capacitance due to any insulation over the winding.

For any small well-designed solenoid coil wound on a phenolic coil form, all of the above factors will be essentially constant for coils within a group of a given design.

*Jeffers Electronics Div., Speer Carbon Co., Dubois, Pa.

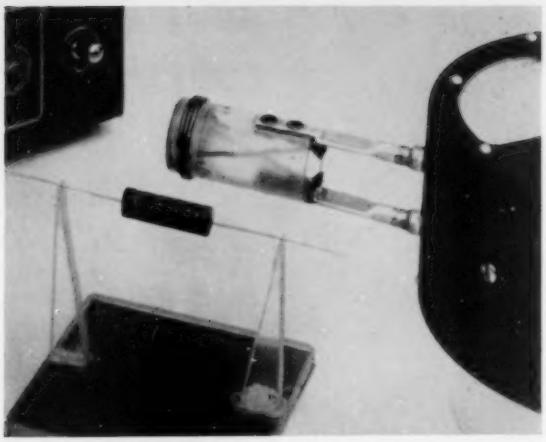


Fig. 2. Grid-dip meter with minimum inductive coupling

The total value of C for a coil on a phenolic form is small, approximately .3 micromicrofarads, with the lead capacitance constituting an appreciable portion of the total. For this reason, any change in lead length results in an appreciable percentage change in both C and SRF.

In the case of a small rf coil wound on a powdered iron coil form, the capacitance due to the coil form alone may be 1.0 micromicrofarads or more, with an appreciable variation within coil form lots. This resulting variation in C gives rise to a variation in SRF that is comparable to, or larger than the variations in SRF due to an inductance tolerance of 10 to 20%. For coils on powdered iron forms, any change in lead length results in a relatively small percentage change in C and SRF because of the larger total value for C.

Some typical SRF values obtained for several coils with various lead lengths are shown in the graph of Fig. 3.

Shortening the coil leads not only raises the SRF nominal, but also increases the percentage variation of SRF values in any lot of coils. Consequently, a larger percentage SRF tolerance, as well as a higher nominal SRF value, may be required after the leads are shortened.

The relationship between small changes in the variables shown in Equation (1) can be represented to a close practical approximation in terms of the following expressions:

$$\Delta \text{ SRF} = -(\Delta L + \Delta C)/2 \qquad (2)$$

where Δ represents a small percentage change (10% or less) from the nominal value.

It can be noted from equation (2) that the sum of any small percentage changes L and C will shift the SRF by approximately one half this amount in the opposite direction.

This method can be used to establish a realistic SRF tolerance in those applications where such control is required. A variation in C of up to $\pm 10\%$ and more can be expected for small rf solenoid coils wound on phenolic coil forms. Similar coils wound on powdered iron coil forms may exhibit a variation in C of up to $\pm 25\%$. Because of the variable C factor, it is impossible to maintain SRF tolerances closer than those derived by equation (2), without resorting to a control or adjustment technique.

SRF control techniques

Special techniques can be utilized to achieve a very close control of SRF for applications where the tuned circuit features of a coil operating at its SRF are desired. For all practical purposes the actual degree of control possible is limited only by the economics involved. Close control of the SRF may be achieved through the use of one or more of the following methods:

1. Holding closer inductance tolerances (for most coils).
2. Adjusting the inductance to control SRF (this method may require a rather broad inductance tolerance).
3. Sorting of the powdered iron forms to minimize variation in the coil form capacitance (applicable only to coils wound on powdered iron forms).
4. Adding capacitance to the coil in the form of a conductive paint on the winding, so as to minimize the percentage variation in the distributed capacity of the coil. (This method can reduce the SRF nominal appreciably.)

Summary

Proper use of the SRF characteristic of small rf coils offers many interesting possibilities for circuit simplicity, reliability, and economy for purchasing and manufacturing to the electronic equipment manufacturer.

1. Controlling SRF is an accurate and convenient method of controlling the distributed capacitance of a coil.
2. There are practical methods available for controlling SRF, usually determined by the economics involved, rather than any limitations of the manufacturing process.
3. A high degree of SRF measurement accuracy is obtainable on a production basis, provided a few basic considerations are observed.
4. The SRF characteristic of a coil should be evaluated in terms of the actual conditions under which it is to be used in the circuit. For example, necessary shortening of leads for installation may increase SRF appreciably.
5. Any arbitrary use of the coil's SRF characteristic as a criterion of quality for general purpose coils is to be avoided, as it may impose unnecessary restrictions on the coil manufacturer.
6. Under proper conditions the SRF characteristic of a small rf coil can be used for:
   a. Simple band-stop filters, simple band-pass filters, blocking or matching impedances.
   b. "Stand off" terminal mounts offer resistive impedance to provide a degree of insulation (comparable to a good quality insulator) for selected frequencies, yet pass other frequencies and dc freely.

END

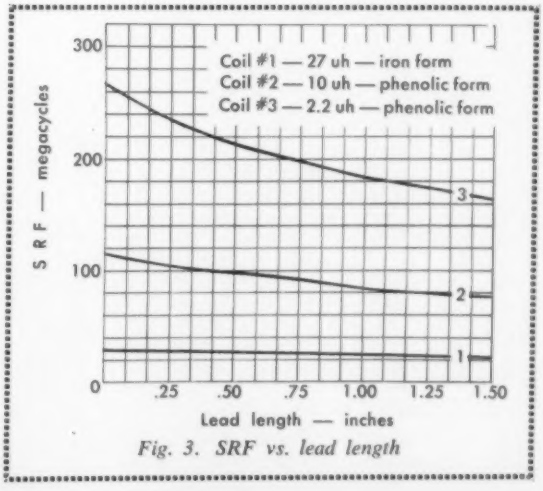
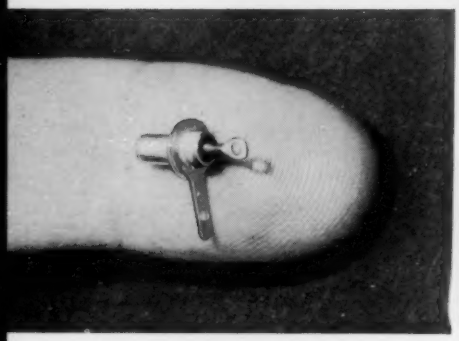
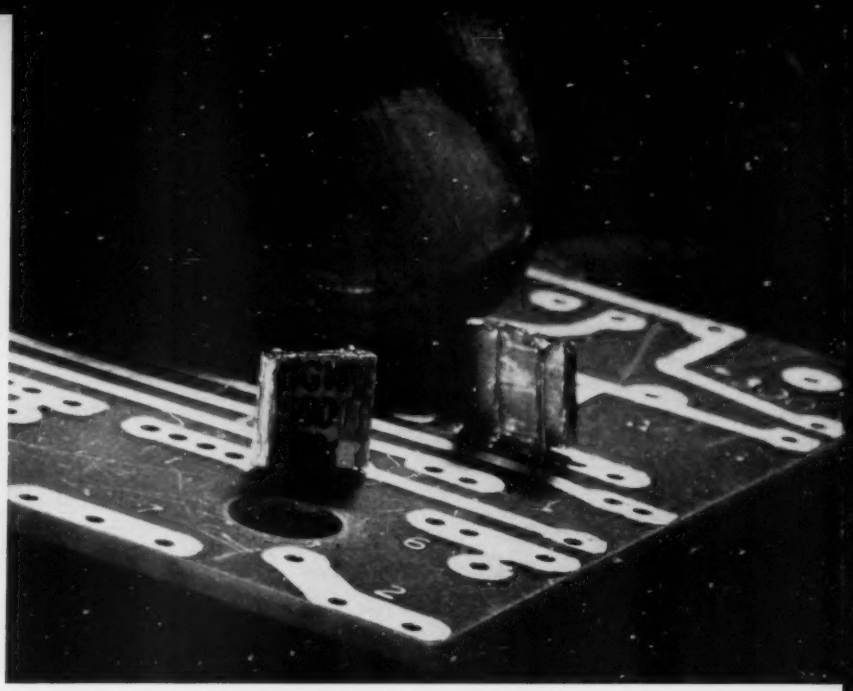


Fig. 3. SRF vs. lead length

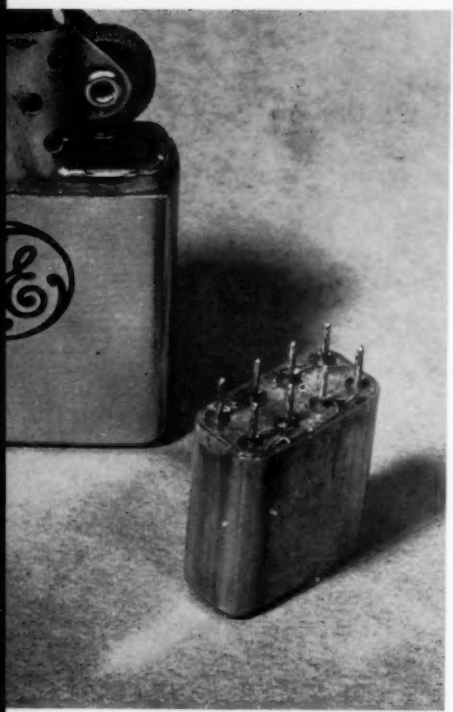
What's new in view



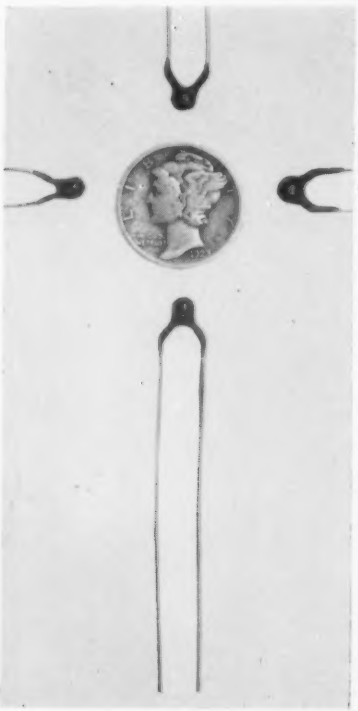
Victoreen Instrument Co. micro miniature cold cathode gas trigger diode tube operates from —65 F to 160 F



Corning Glass Works fixed glass capacitors pack as much as 1,000 uuf at 300 v into 0.010 cubic inch



General Electric hermetically sealed dpdt relay has been developed for plug-in use on printed circuit boards

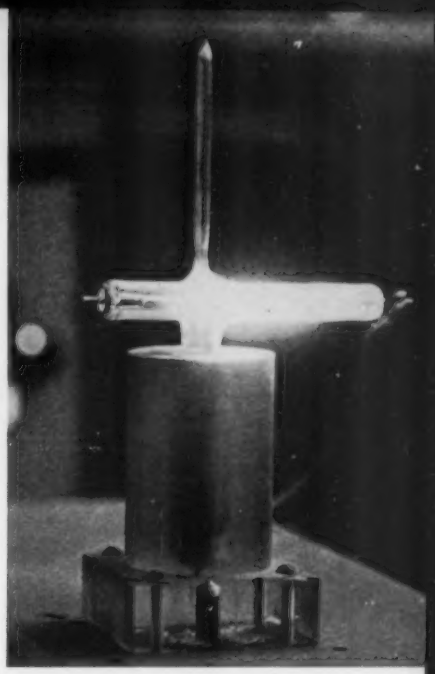


These four ceramic capacitors made by Telecomputing Corp. would not cover dime. Sizes are up to .056 uf

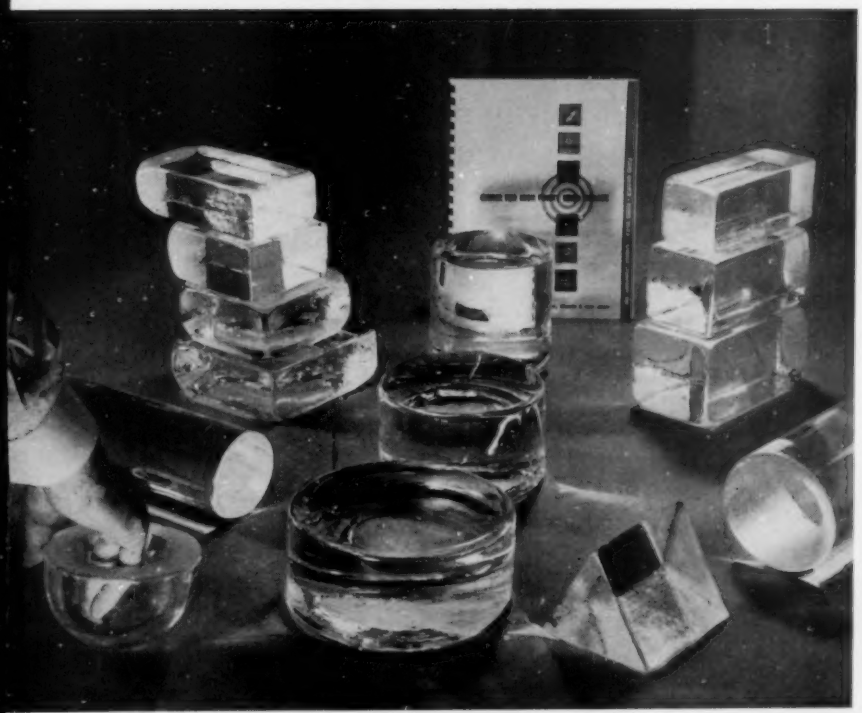
This glaswitch relay by Revere Corp. of America has contacts sealed in a glass envelope filled with nitrogen

Components grow smaller, better

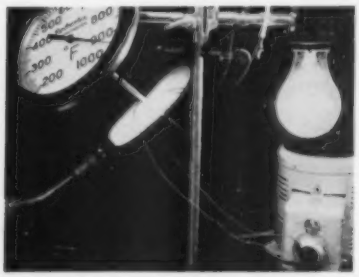
Levinthal Electronic Products grew this ingot to make thallium-activated sodium-iodide scintillation crystals



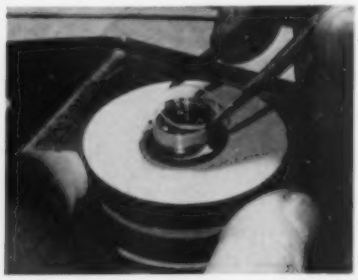
Vacuum switch made by Pioneer Electronics Corp. was still going strong after completing 77 million cycles



New fusing process used by Engelhard Industries, Inc. permits subsequent forging of quartz into special shapes



Ceramic - coated Ceratemp flexible magnet wire by Hitemp Wires, Inc. will operate continuously at 1,000 F



Operator fits a Linde Air Products Co. synthetic sapphire window to an infrared thermistor bolometer

CEE called on some engineers to find out what they thought of last year's IRE Canadian Convention, and to find out what they would like to see and hear at this year's show. These are their comments and suggestions on the exhibits and the technical papers

Engineers air their views on the IRE Canadian Convention

D. H. Johnston, Manager, Engineering Dept., Dominion Electrohome Industries Ltd.

The majority of engineers are cooped up in their labs and offices all year. It is an excellent thing for them to get out to compare notes with other engineers, get fresh ideas and keep track of the electronics industry generally. Our company recognizes the value of this philosophy and backs it up in a tangible way.

We encourage our engineers to attend the IRE Canadian Convention and give them time off to go to Toronto. Those having a direct interest in the event, such as authors of papers or someone after a specific bit of information, are sponsored by the company.

The Canadian show has changed things for us in some respects. Several of our engineers used to go to the National Convention in New York each year, but the number has been reduced now. Some still go, but the company is much more selective. They prefer to send them to Toronto. Apart from the obvious reduction in cost, there is much greater value in having our engineers exchange ideas with their fellow Canadian engineers.

E. Leaver, President, Electronic Associates Ltd.

To set up a show of this nature and size, and to reach the high professional calibre which has been attained is a great achievement. The IRE is to be congratulated for the excellent job done to date.

This Canadian show certainly is an ambitious project and it may be a bit difficult to maintain it at the present level unless the business climate in Canada improves. However, I hope they will be able to continue because it is a good show.

One thing I would like to see this year is more of the exhibitors swinging in behind the Electronic Industries Association program of "Buy Canadian." This may be a rather touchy theme since a great deal of the show money comes from companies outside Canada, but I think that the Canadian developments should be shown. As a nation we are becoming aware of our ability and our potential. This should be shown because it helps to give the visiting students and public a true picture of what the electronics industry in Canada is doing and can do.

Emphasis on the "Buy Canadian" theme would have another benefit. It would show many of the government people that the industry is mature and capable of producing many of the items currently being imported.

At the National Convention in New York last spring there was a trend among the technical papers. Most of them were designed to present information to a wider audience. That is, they were not quite so technical as in previous years so that more engineers could be informed of the developments taking place in many branches of the industry.

In this connection I would like to offer a suggestion which could be followed now that the Canadian IRE has decided to publish a convention record. Papers could be prepared in two parts. The first part, for delivery at the convention, could contain the general information. The second part, or appendix could have detailed information, references, mathematical proofs, etc. In general, the appendix should have the information that requires deep concentration at the reader's leisure for maximum appreciation.

William Paul, Ph.D., Dept. of Pathological Chemistry, University of Toronto. Author of paper "Oximetry" 1957.

Being in a specialized field it is only natural that a large percentage of the exhibits would have little direct bearing on my work. Even at that, however, about one quarter of the show was of interest to me. I saw a few things there that I had heard about and wanted to see, so the show was worthwhile from my point of view.

The medical papers were fascinating. In fact I sat through all of them except one. The subject material was good and the delivery was on a high level—as good as the standard of any other sessions I have attended.

The papers that suffered most from poor delivery were the ones that were read. In my opinion, this is never as effective a delivery. The best ones are where the author can get up and talk about his subject with little reference to notes.

For more news on this see page 34.—Ed.

Probably one reason that the technical papers are so well delivered is the help given by the IRE committee. That forceful circular they send out to all the speakers is very good.

H. Dulmage, Project Engineer, Collins Radio Company of Canada Limited.

Due to a deadline on delivery of some equipment during October of last year I had only three hours in which to make a tour of the IRE show. That really wasn't enough time to get a good look at it.

However, I did think that the show contained a high percentage of complete manufactured products or assemblies. As an employee of a manufacturing company, I was looking for new components.

Our work at Collins Radio has required us to find components which are not generally on the market and are not advertised too widely. I can't recall that we, as a group, were able to locate any such components at the exposition.

It's just by hard work that we manage to dig out the components we need. These are in the order of rectifiers, resistors, capacitors and various other electronic components for high temperature operation—higher than has been normal in previous equipment. We would like to find some of these components at the IRE exposition this year.

Electronics firms show faith in future

Wide range of products will be shown at IRE exposition

Almost 90% of available booth space for the 1958 IRE Canadian Convention and Exposition had been reserved at the time we went to press. This partial list of exhibitors gives an indication of the wide range of components, equipment and services that will be on display in the Automotive Building, Exhibition Park, Toronto, on October 8, 9 and 10. Watch for additional names in CEE's September issue, and a complete, detailed preview of the show in October's special editorial section.

Exhibitor — **Booth No.**

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Beatty Bros. Ltd., Fergus, Ont. 162
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Eitel-McCullough, Inc., San Bruno, Calif. 155
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M. J. Howard & Co., Ottawa E12

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Masson Seeley & Co. Ltd., Rexdale, Ont. E18, E20
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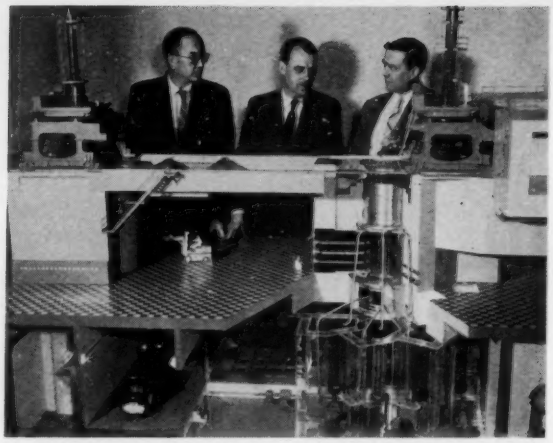
World scientists prepare for Geneva conference



A. G. Ward, Dr. G. C. Butler and Dr. W. B. Lewis of AECL check over model of NRU reactor which will be part of Canadian display at the Geneva Conference, Sept. 1 to 13

On September 1, scientists from all parts of the world will be assembling at Geneva for the second United Nations International Conference on the peaceful uses of atomic energy. A total of 5,000 scientists, engineers, government officials, executives of private companies and others are expected to attend the meetings.

The first United Nations atomic conference was held in Geneva in August 1955 and was attended by 3,000 delegates and observers and about 1,000 representatives of newspapers, radio stations, magazine and television stations. Just over 1,000 scientific papers were submitted in the 1955 conference. About twice as many papers will be submitted to the forthcoming conference and the United Nations intends to publish them in 33 volumes.

Canada's exhibit covers the full range of atomic energy developments in this country from the uranium industry through fundamental and applied research to radioactive isotopes and atomic power. Included in the exhibit are 15 models of atomic power reactors, cancer treatment machines, a uranium mine mill, the Port Hope refinery of Eldorado Mining & Refining Ltd., the research and production reactors at Chalk River and a beta ray spectrometer.

Operating equipment included in the display are a cancer treatment machine, a radiography machine and a Gammacell. The latter contains 5,000 curies of Cobalt 60, the gamma rays from which are used to sterilize materials and study the useful effects of radiation on such things as lubricants, plastics and drugs. Demonstrations of the uses of the machine will be given during the conference.

Other projects will be displayed in photographs and three color films, each with a running time of 30 minutes.

The Canadian delegation to the Geneva conference will be under the leadership of Dr. W. B. Lewis, vice-president of Atomic Energy of Canada Ltd. Forty-nine papers, on virtually all aspects of atomic energy, are to be read by members of the Canadian delegation.

Thermonuclear power

A subject likely to be discussed at great length at the second United Nations International Conference on the peaceful uses of atomic energy is thermonuclear energy. World attention was focused on this subject at the beginning of the year when British scientists at Harwell announced the apparent success of Zeta.

At that time the scientists expressed the belief that they had obtained a true thermonuclear reaction in the machine.

While British scientists appear to be directing most of their research into the pinch method of controlled thermonuclear reaction, American and Soviet physicists appear to be approaching the problem along several different lines.

So far the American scientists have announced four different methods being tried by their research groups. They are the pinch method, the mirror method, the stellarator and the hot-ion injection method. Operating displays of these four types of devices will be shown at the Geneva Conference.

Although full plans have not been divulged, Soviet physicists participating in the Geneva Conference will describe what they are doing, in particular work very similar to that being done in Britain.

Particle accelerators

Another subject that will be closely watched at the Geneva Convention is the work being done on high powered particle accelerators. It was at Geneva in 1955 that the Soviet scientist V. I. Veksler first announced that the USSR was building a proton synchrotron capable of accelerating particles to an energy of 10 billion electron volts.

This machine located at Dubna, about 95 miles north of Moscow, went into operation in early 1957.

The United States Atomic Energy Commission, at its Brookhaven National Laboratory, is building an alternating gradient synchrotron designed to provide a beam of protons of 25 to 30 Bev energy. It is expected that this will be ready for systems testing in 1960.

Meanwhile the USSR has announced plans for a 50 Bev accelerator.

The rapid growth of nucleonics, like that of electronics, is one of the more spectacular events of the present time. And since these two industries are so closely related in many ways, CEE will report on those important developments in the field of nucleonics which have an effect on the field of electronics.

This is the first of the bi-monthly news reports.

Van de Graaff exceeds 13 Mev

Just after the July issue of CEE went to press with the two feature stories on the Tandem Van de Graff, data was released on the initial tests of the machine. These tests were carried out at the plant of High Voltage Engineering Corp.

The Tandem Van de Graaff has accelerated protons to an energy of more than 13 million electron volts (MeV) and oxygen nuclei to more than 30 MeV, with an energy precision of better than one tenth of one per cent. This is the first time that particles have been produced at these energies with such precision.

In a series of experiments with the new accelerator, Chalk River and HVEC scientists studied proton-neutron thresholds and relative neutron yield in a number of different elements ranging in atomic mass from that of lithium to that of gold.

For your library

Book provides data for expanding field of control engineering

Control Engineers' Handbook

John G. Truxal, Editor-in-Chief. McGraw-Hill Co. of Canada Ltd., Toronto; 1105 pp; $22.20.

Reviewed by: Dr. G. R. Slemon, Professor of Electrical Engineering, University of Toronto.

The value of a handbook is that it is a concise collection of the theory, practice and essential data concerned with a particular field of activity within the covers of a single book. Professor Truxal and his thirty-six distinguished contributors have done an admirable job in gathering together for the first time much useful information on the general theories of control systems and on the many components of particular interest to the control engineer.

Section 1 of the handbook is a brief collection of tables and mathematical relations. Sections 2, 3 and 4 are devoted to control system theory and design. The authors have quite rightly placed the emphasis on the components of control systems rather than on system theory. Of the 19 sections of the handbook 14 are devoted to a discussion of the theory, performance and application of the individual components of control systems. The scope of this coverage can be seen from the following representative section titles; computers, magnetic amplifiers, contactors, actuators, transducers, mechanical components, hydraulic and pneumatic components.

It is of particular interest that these topics are treated from the unified and biased point of view of the control engineer. Thus an engineer who is experienced in one area of control will find in the book an easy introduction to other areas of control.

Perhaps it is unfair to expect a handbook to be more than a reflection of the technical literature to date. Most of the papers and textbooks written in this field have been concerned with the theory, analysis and synthesis of control systems. There has been a dearth of practical numerical component data. The handbook suffers from this same limitation. The authors have dedicated their book "to the continuing explosive growth of control engineering." Possibly they have been overawed by the explosive nature of their subject matter and have been reluctant to include numerical data which, while very useful at the moment, might in a fairly short time become obsolete.

The handbook is well indexed, and has good binding and printing. Although it may be more of a condensed textbook than is appropriate for a handbook it fills a definite need in the control engineer's library.

The Metallurgy of Vanadium

William Rostoker. John Wiley & Sons, Inc., New York; 185 pp; $8.50.

This book presents a unified treatment of the extraction, physical and mechanical properties, and processing of vanadium. It records the latest scientific data available.

Zone Melting

William G. Pfann, John Wiley & Sons, Inc., New York; 236 pp; $7.50.

Reviewed by: Dr. H. Pullan, Research Laboratories, RCA Victor Company Ltd., Montreal.

The relatively new field of zone-melting, on which this is the first book, is best known through its use in purification, called zone-refining. This is the main emphasis of the book, which in four of its nine chapters deals with the theoretical aspects, the practical techniques, the application to specific materials ranging from tungsten to sea-water, and the possibilities of continuous zone-refining, which has commercial implications.

Subsequent chapters discuss zone-levelling, in which an impurity can be distributed uniformly along a bar of material, single-crystal growth, and special applications in which the normal process is disturbed, to produce, for example, p-n junctions.

Much information is given which will help to decide whether a particular zone-melting process is feasible, and the book's usefulness will certainly not be confined to those working in solid-state physics. It is a clear, well laid out book, written by the man who has played the key role in developing the subject.

Glossary of automation terms

NOMA Automation Committee, National Office Management Assoc., 1931 Old York Rd., Willow Grove, Pa.; 38 pp; $2.00.

Review courtesy of Denham & Co., Detroit.

Webster is having a rough time. English as she has been spoken may have been all right for our parents and for you and me. But it won't be for future generations. Automation is the guilty party. It is creating new meanings for many of our most common words.

In this glossary we find that an "error" must never be confused with a "mistake." An "error" it says, is the amount of loss of precision in a quantity. A mistake is something quite different. A "file" we discover is "a sequential set of items." A "band" is a group of recording tracks. "Bit" is defined as a "binary digit," the first word of which, in turn, means "a characteristic involving a selection in which there are only two possible alternatives."

When it gets to the word "memory," the glossary simply shudders, tells you that this is not a good word and refuses to define it. Instead it says you should always say "storage" (let's see now—if my storage serves me right . . .).

P.S.—We found a word that means exactly what it says. A "Williams Tube," used in automated devices, actually means "a tube invented by a man named Williams." The definition even gives Mr. Williams' address.

The Computer Journal

A new journal is being published by the British Computer Society to record the British contributions to the development of computer techniques. The publication will also carry articles surveying progress in different fields of computer development which have taken place in other countries.

Catalogues and brochures from the manufacturers

Decade counter tubes. Electrical characteristics and application data on the most popular counter tube types are given in an eight-page brochure. Sylvania Electric Products Inc., New York. (101)

A better foundation for printed circuitry describes eleven grades of phenolic copper-clad laminates. National Fibre Co. of Canada, Ltd., Toronto. (102)

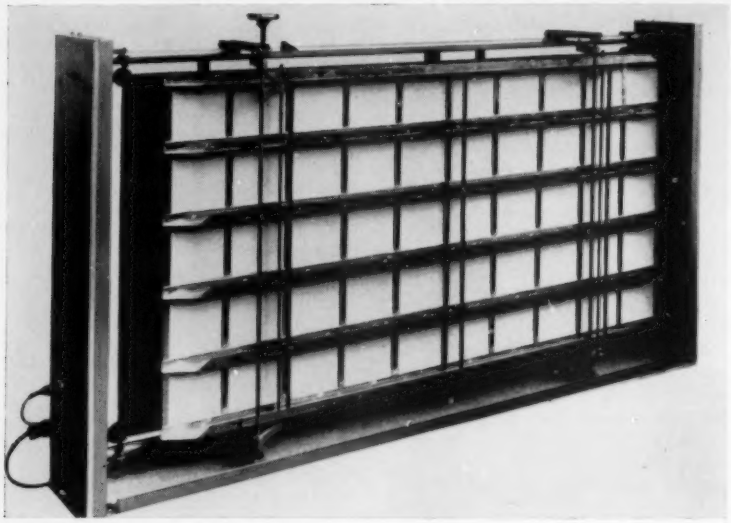
Nickel-iron magnetic alloys. Full engineering data on alloys 48 Ni and 48 orthonik are given in 64-page book. Armco Steel Corp., Middletown, Ohio. (103)

Transistor interchangeability chart covers all E.I.A. registered types comparable to G. T. types. General Transistor Corp., Jamaica, N.Y. (104)

The use of pH meters in titration work is described in two application data sheets. Beckman/Scientific Instruments Div., Fullterton, Calif. (105)

Reverberation unit produces echo effects

The Viditon Corporation Ltd., has developed a reverberation unit to produce echo effects for radio, T.V. and recording studios. It can be operated by remote control which permits it to be installed wherever space is available. Model EMT 140 measures approximately 8 ft. x 2 ft. x 4 ft.



Reverberation time ranges from 0.8 to 6 seconds. Distortion-free output is claimed between 30 and 12,000 cycles.

Viditon Corp., Ottawa. (106)

Two servo elements

To meet the increasing demand for low weight, small size components, the model 08M10A1, 26 volt, 400 cps, size 08 servomoter has been developed. Conforming to the standard 08 frame, this miniature motor has an over-all diameter of 0.750 in., a length of 0.93 in. from front face to ends of connexion tags, and a shaft extension of 0.156 in. The shaft is splined in the form of an involute pinion of 13 teeth 120 D.P., 0.1245/0. 1240 in. O.D. 0.1083/0. 1078 in. P.C.D., 20 deg pressure angle.

Another new product is the Size 11 Linvar (Model 11M16A1, 115 v or 26 v, 400 cps). This small size, low weight instrument, housed in a standard Bu-Ord Size 11 synchro frame, has a voltage output proportional to rotor angle rising to 42.5 volts. The linear relationship of ±¼% extends over the range ±85 degrees from the zero output position, and is achieved by a special patented design of the rotor and slator laminations which gives a smooth variation of output voltage devoid of any fluctuations due to tooth ripple. The Linvar can be applied to satisfy the requirements of analogue computation, remote control or indication, and may be operated by mechanical measuring devices e.g. strain and deflexion gauges, weighing machines etc., where an a.c. output voltage varying linearly with deflexion is required.

Muirhead Instruments Ltd., Stratford, Ont. (107)

Induction heater

The 10 kc current for this induction heater is supplied by a totally enclosed, water cooled 30 kw, 50 hp motor-generator set. It is floor mounted in a 60 by 39 inch space beneath the control and output station table.

The high voltage output provides 100, 200, 300, 400, 500, 600, 700 or 800 volts output by changing readily — accessible links on the secondary of the auto-transformer. This output can be used for a variety of melting, heating, annealing and brazing operations.

The low voltage output is used for many surface hardening, melting, heating and brazing operations where relatively high power densities are required. The low voltage terminal is fed from a high frequency fixed ratio transformer used in conjunction with the above auto-transformer to obtain open circuit voltages of 12½, 25, 37½, 50, 62½, 75 and 87½ volts.

Canadian Westinghouse Co. Ltd., Hamilton. (108)

AM broadcast transmitters

The BTA-5K/10K Broadcast transmitter consists of four rugged steel and aluminum cabinets, the modulator, the power amplifier, the exciter and the power rectifier. These individual cabinets simplify installation of the transmitter. The externally located air-cooled plate transformer is completely enclosed and shielded, and it does not require a fireproof vault. Lightweight transmitter cabinets, self contained components and preformed wire cable, supplied with the transmitter, simplify the installation and reduce time to a minimum.

All components are conservatively rated and an increase to 10 kw may be done easily and inexpensively without increasing the number of cabinets or the floor space. Conversion can usually be accomplished without loss of air time.

RCA Victor Company Ltd., Montreal. (109)

Test picture tube

Marconi test picture tube model 8YP4 has been designed to test both the standard 90 deg television tubes and the new 110 deg tubes. It has a conventional 8YP4 shell base because of its proven durability under repeated use. However, two adaptors are packed with every tube — one for 110 deg and one for 90 deg receivers. The tube is designed to operate from a filament supply of 6.3 volts at 600 ma, 6.3 v at 450 ma or 8.4 v at 450 ma.

Other features include electrostatic self-focusing using internal connections between grids 2 and 4; approximately 80% light transmission; and a white P4 phosphor which has short to medium persistence.

Canadian Marconi Co., Toronto. (110)

Quick reset counter

The Trumeter predetermined counter is provided with a non-inductive microswitch operated by the counter mechanism. It can be used on machinery to control over and under runs. The switch contacts have a maximum rating of 600 volts, 2 amps, and can be operated on 110 volt supply with a maximum current of 10 amps. Other values of supply voltage may be used with a proportionate reduction of the current rating. Maximum counting rate is 5,000 rpm or 1,000 strokes per minute. The counter can be reset while the machine is in operation. Once the control impulse is given it is sustained until reset.

Dominion Electrohome Industries Ltd., Kitchener, Ont. (111)

Hi-fi equipment and enclosures

The following components and enclosures are being offered by Canadian General Electric Co. Ltd. as part of their hi-fi and stereo equipment.

"Stereo Classic" model TM-2G is a compatible stereophonic and monaural high fidelity tone arm. It has a two-step adjustment for precise setting of the tracking force between 0 and 6 grams. It is designed to accommodate only G.E. stereophonic and VR-II monaural cartridges. The arm will play either stereophonic or monaural records up to 12″ in diameter. Its height is adjustable for the turntable, from ⅜″ to 2¼″ above the motor board. Maximum tracking

error is 2 deg.

Two magnetic variable reluctance stereophonic cartridges are available. The "Golden Classic" model GC-7 will have a 0.7 mill diamond stylus. "Stereo Classic" model "CL-7" will have a 0.7 mill synthetic sapphire stylus. Both have a frequency response from 20 through 17,000 cycles. The stylus is inserted directly through the armature, which floats in damping cushions. The effective mass of the stylus is reduced to approximately 2 milligrams.

Model LH-6 speaker and enclosure combination includes a 6″ woofer speaker, a new 2¾″ tweeter and a crossover network in an infinite baffle. Frequency response is 70 to 13,000 cps, ± 6 db. Power rating is 20 watts and the crossover frequency is 1500 cps. Outside dimensions are 9″ x 17⅝″ x 8⅜″. The speakers and crossover network, along with instructions for building the enclosures are available in kit form.

Equipment cabinets are available in a choice of mahogany, blond oak or cherry wood veneer finishes. Over-all dimensions are 31 inches high, 39¾ inches wide, 16 inches deep. They have a record changer-turntable compartment, amplifier and tuner compartment, and two record storage compartments.

Canadian General Electric Co. Ltd., Toronto. (112)

Sidereal rate turntable

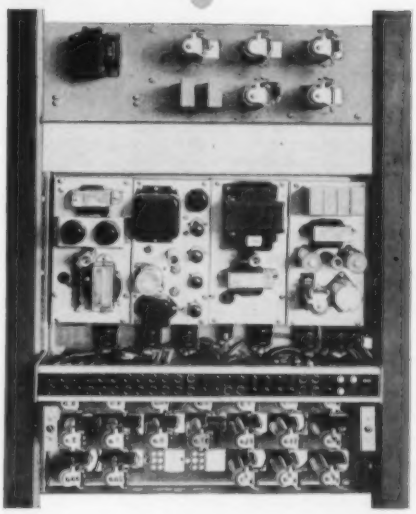
Model 063 sidereal rate test turntable measures error or drift of gyroscopic and inertial equipment. The unit is a positively driven, equatorially mounted platform which rotates at pre-set rates equal to the earth's rotation or at multiples of this in either direction. With the effect of the earth's rotation nullified, the equipment under test is isolated in inertial space or its performance under known drift rates can be evaluated. Position to an accuracy of ± 3 seconds of arc is continuously maintained throughout a 360 degree rotational cycle.

J. W. Fecker, Inc., Pittsburgh. (113)

(Continued on page 46)

SECODE's
SELECTIVE CONTROL DEVICES

New COT-2
Dial Terminal
Cuts the Cost of Radiotelephone Service



COT-2 Terminal using modular construction, with units mounted back-to-back. Terminal occupies only 17½" of standard 19" rack space. Switchboard line termination unit at top.

Features

Full Manual Dial Terminal... includes hybrid and balance unit, line coil and relay unit, dual tone signaling oscillator, translator unit, power supply, receiving relay unit, jack field and indicator assembly, and chassis assembly with control and timing network.

Complete Compatibility... can be installed with no switchboard modification, two wire to four wire conversion, meets all Bell system standards for mobile telephone service. Standard tollboard operator techniques are used in mobile telephone service.

Low Cost and High Reliability... priced at one-fourth the cost of comparable terminal equipment, the COT-2 has full telephone reliability.

Flexibility... as the system grows, additional operator positions can be multiplied without limit, optional equipment includes VOGAD amplifier, transmitting line unit, dial repeater, receiver diversity, and auxiliary alarms.

Secode's new Model COT-2 Manual Dial Terminal performs the basic functions for the operation of a base radiotelephone facility over a two wire line from a mobile operator's switchboard. Secode dial signaling, fully compatible with Standard telephone practice, is used to contact mobile or fixed mobile.

With Secode's new MTS terminal, the benefits and qualities of land-line operation can be economically extended to rugged and remote areas. Your nearest Secode engineering representative will be pleased to give you complete information:

TELE-RADIO SYSTEMS, LTD., 3534 Dundas Street West, Toronto 9, Ontario, Phone Roger 2-8284; CANADIAN ELECTRONICS LTD., 109 Street at 107 Avenue, Edmonton, Alberta, Phone 4-6451; and WESTRONIC ENGINEERING SALES LTD., 1451 Hornby Street, Vancouver, B.C., Phone Mutual 1-0107, or write directly to Dept. 778

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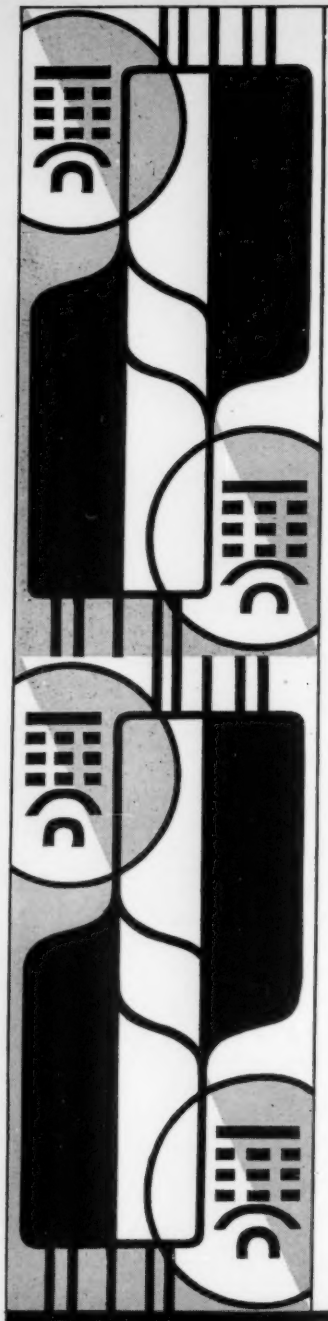

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Transmitter has remote control

The base station and antenna of series WPM-10 radio systems can be mounted in any location for best transmission. The base station is then operated by a remote console from a local office. The base station is completely weatherproof and can be pole, wall or floor mounted in any exposed location. Transmitter, receiver, power supply, battery charger, remote terminations and batteries are all mounted in one selfcontained cabinet.

The transistorized remote control console provides facilities for "push-to-talk" transmitter control and selection of frequencies. Several consoles can be paralleled to provide transmitter control from different locations and the feature is "off the air" intercommunication among consoles or between consoles and base station.

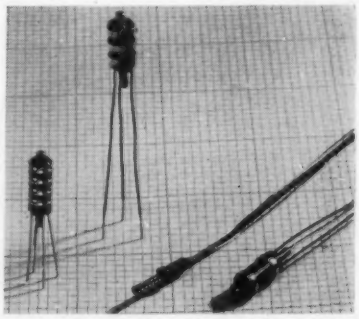
If line power fails, both remote control and base station instantly transfer to battery power.

Canadian Westinghouse Co. Ltd., Hamilton. (114)

Sub-miniature slip rings

Sub-miniature slip rings for gyro, syncro and resolver components and switching computators consist of solid turned rings of coin-silver, platinum-silver or gold alloys. Plaskon Alkyd 446 is utilized in the molding to impart temperature resistance, dimensional stability and high dielectric strength.

The rings are miniaturized to 0.23 in. (for two rings), .035 in. (for three rings), 0.60 in. (for nine-ring assemblies), they are spot welded to the leads to assure permanent and noise free connections.



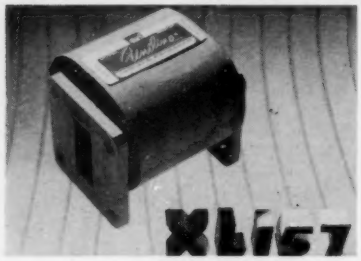
Electro Development Co., Van Nuys, Calif. (115)

Ferrite load isolator

Used to provide substantial isolation between a microwave source and its load, load isolator model XL157 removes the reactive loading effect caused by long transmission lines or the frequency pulling of the magnetron or klystron.

Operable over the band 8.5 to 9.6 kmc, it gives 15 db isolation with an insertion loss of 0.5 db. Input vswr into a flat load

is 1.15. Peak power with a two to one mismatch is 300 kw and average power under the same conditions is 300 watts. Operating throughout the temperature range minus 55 to plus 125C, the XL157 has UG-51/U flanges to mate with RG-51/U waveguide.



Cascade Research Division of Monogram Precision Industries Inc., Los Gatos, Calif. (116)

Picture and sound generator

Model 1150 automatic picture and sound generator has been developed by B & K Manufacturing Co. for use on closed circuit TV systems. The unit transmits picture from 35 millimeter slides, with simultaneous sound, through the customer's own closed circuit TV channel. Operation may be continuously automatic, manual, or remotely controlled.

It provides community TV or master antenna systems with a private closed circuit channel, without need of camera equipment for video and audio announcements, spot advertising during off-air time, station breaks, system testing, or special situations.

The removable slide magazine shows up to 28 standard 35 mm (2 x 2) glass slides. It can be set for automatic, manual, or remote controlled operation of full or partially filled magazine. For continuous automatic showing the slide changer recycles itself and the variable timer permits selection of time intervals from 5 to 75 seconds. The scanning system uses low-replacement cost flying spot scanner tube.

Two audio input channels are provided. A function switch permits using tape, tuner, microphone or external audio source and switching from one to another. Response is 80 to 13,000 cps with FCC standard pre-emphasis. Power input is 117 volts 50-60 cps.

Atlas Radio Corporation Ltd., Toronto. (117)

Operators' telephone set

Utilizing reinforced resilient nylon molding, this operators' telephone set weighs less than 3 ounces. The nylon molding facilitates cleaning and virtually eliminates breakage. The set is available with an ivory finish.

The miniaturized rocking armature receiver and the new transmitter unit provide better reception and transmitter characteristics than previous models.

Standard Telephones & Cables Mfg. Co. (Canada) Ltd., Montreal. (118)

(Continued on page 48)

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New products — cont.

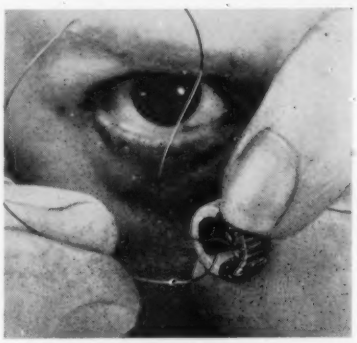
Synchronous receiver

Model D-885 synchronous receiver is designed to give a remote indication of angular position. The receiver can be operated remotely from a commutator or potentiometer-type transmitter. When the receiver is used with a commutator-type transmitter, the permanent magnet rotor responds to movements of the transmitter in 30 deg steps. With a potentiometer-type transmitter, rotation is continuous with a following accuracy of ± 3 deg. The maximum output torque of the receiver is 0.5 oz. in. when the rotor is 90 deg from its correct line-up position. The torque gradient is 0.0085 oz. in. per degree.

Muirhead Instruments Ltd., Stratford, Ont. (119)

Bobbin cores capped with glass polyester

"Poly Cap" tape wound bobbin cores are stainless steel bobbins capped with a tough glass polyester. This offers production advantages since the rigid structure of the cap allows freedom of handling on the assembly line without the necessity of tweezers or special tools.



The tape wound bobbin cores have temperature stability, low coercive values, and high saturation densities. They may be used in shift registers, coincident-current matrices, core-diode memory systems, harmonic generators or pulse transformers.

Magnetics, Inc., Butler, Pa. (120)

Precision pots for servos and computers

These ⅞ inch and 1 1/16 inch diameter 10-turn precision potentiometers have been developed for servo and computing systems where performance under wide temperature and vibration environments are required. Resistance range is 2,000 to 100,000 ohms with linearity of 0.03% above 5,000 ohms. The housing is available in either high temperature resistant glass-epoxy or anodized aluminum cases.

Philips Electronics Industries Ltd., Toronto. (121)

(Continued on page 52)

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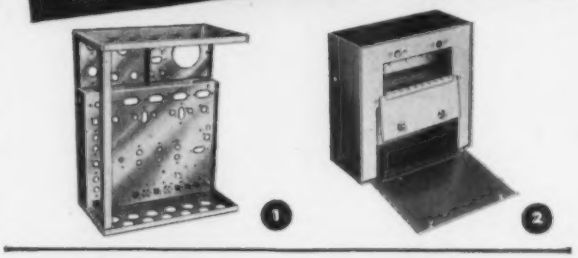

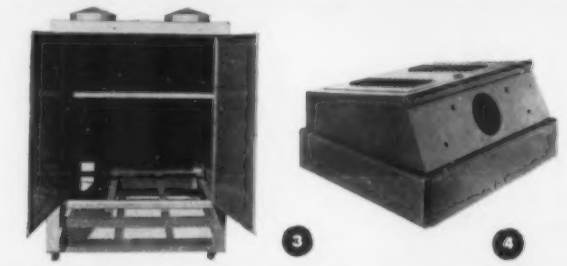

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Precision Instrument Co., San Carlos, Calif. (122)

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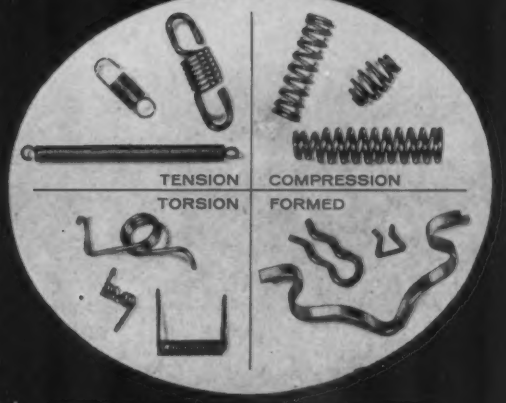

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Stereo recording on discs will boost the industry sales

Sales managers are predicting a major break through in sales of audio equipment this year. Stereo disks with compatible 45/45 cartridges are stimulating consumer interest.

The president of one large U. S. corporation expects that sales will run as high as $1 billion per year for records and equipment.

Sales in Canada are expected to pass the million dollar mark.

While some of the Canadian manufacturers are moving cautiously, others will be showing new stereo audio equipment this fall. All of them have plans on the drawing board for quick entry into the field and standard models now in production are being modified so that they can be converted at a later date if the owner so desires.

The sale of records is expected to jump sharply — both stereo and monaural. Audio men predict that the consumer interest will be stimulated by the stereo discs and this in turn will help the sale of monaural discs. Some recordings offer no real advantage in stereo. This includes solo vocalists or instruments, and small groups. The source is essentially a "point" source which can be presented as realistically with monaural as with stereo recording.

Of special interest to the engineers will be the session of stereophonic disc recording and audio to be held at the IRE Canadian convention this fall.

electrical insulation materials at high temperatures. Work will start this fall under the direction of Dr. John Hart to investigate the properties of electrical insulation at temperatures as high as 1800 C.

An estimated $100,000 will be required during the next five years to finance the program. Research grants will be sought from industry, foundations and institutions established to encourage scientific research.

Magnetic recorder gets a new head

Sonograph Ltd. has just unveiled its new office dictating machine using magnetic belts. In the Sept. issue of CEE design engineer Paul Hallam describes the new head which he developed.

On July 1, the Trans-Canada microwave system went into service from coast to coast. Now Mel James of Bell Telephone will discuss the equipment used in the TD-2 microwave link.

As part of a college thesis, K. J. Asten carried out an extensive survey among the users of good hi-fi equipment. His findings will be presented in the Sept. issue of CEE.

IGY work to continue

The International Geophysical Year is now entering the final six months of its official existence. However, there's every indication that much of the work started during the IGY program will be continued indefinitely. Many scientists and organizations intend to continue joint observations, at least on some problems. Such a decision has already been taken as regards investigations in the Antarctic.

The geophysical stations set up for IGY probably will continue their work and become permanent stations.

Carleton University starts research

National Research Council has given Carleton University a $10,000 grant to launch a research program concerned with the performance of

COMING EVENTS

August

5-8 AIEE-IRE Nonlinear Magnetics and Magnetic Amplifiers Conference. Los Angeles, Calif.

18-22 International conference on semiconductors. University of Rochester, Rochester, N.Y.

19-22 Western Electronic Show and Convention. Los Angeles, Calif.

19-22 AIEE Pacific General Meeting. Hotel Senator, Sacramento, Calif.

September

1-14 Second International Exhibition of the Peaceful Uses of Atomic Energy. Geneva, Switzerland.

7-11 World Power Conference. The Queen Elizabeth Hotel, Montreal.

15-17 Power Industry Computer Application Conference. King Edward Hotel, Toronto.

16-20 International Nuclear Electronics Conference. UNESCO House, Paris, France.

24-25 IRE-AIEE Industrial Electronics Conference. Detroit, Mich.

October

8-10 IRE Canadian Convention. Exhibition Park, Toronto.

13-15 National Electronics Conference. Chicago.

22-24 Fifth National Vacuum Symposium. San Francisco.

26-31 AIEE Fall General Meeting. Pittsburgh, Pa.

Canadian and American engineers are finalizing plans for the AIEE Power Industry Computer Application Conference to be held in Toronto, Sept. 15-17. Seated l-r: J. T. Fisher, Bell Telephone; J. R. Leslie, Ont. Hydro; George Fraser, Toronto; F. Heath, CGE; Dr. G. R. Slemon, Univ. of Toronto; E. A. Ricker, Ont. Hydro; J. Aitcheson, IBM; L. B. Levesconte, Sargeant & Lundy, Chicago; F. J. Maginniss, GE, Schenectady; F. L. Lawton, Aluminium Labs.; R. M. Clark, C.N. Tels. Standing l-r H. R. Davis and R. B. Steele, C.N. Tels.; R. J. West, CLM; H. M. Sweezie, Toronto Transit Comm.; F. M. Longstaff, Ferranti-Packard.

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U. S. Air Force personnel remove 25,137 hour klystron from advanced Pole Vault base. Department of Defense Photograph.

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The exceptional performance of these tubes under the difficult logistical and environmental conditions of the far north is indicative of the reliability and conservative rating of performance-proved Eimac external-cavity klystrons. Eimac amplifier klystrons are now being used extensively for tropo-scatter communications throughout the United States, Canada and other regions of the world. Eimac klystrons for communications and pulse applications are now available covering frequencies from VHF to SHF and to multi-megawatt output powers.

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